Ontario Geological Survey

Report 192

Geology of the

Cowie Lake Area

District of Algoma

By

E.C. Grunsky

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and the
Ontario Government Bookstore, 880 Bay Street, Toronto.
Orders for publications should be accompanied by cheque or money order,
payable to the *Treasurer of Ontario*

ISSN 0704-2582
ISBN 0-7743-4691-4

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Grunsky, E.C.
1980: Geology of the Cowie Lake Area, District of Algoma; Ontario Geological Survey Report 192, 67p. Accompanied by Map 2426, scale 1:31 680 (1 inch to ½ mile).

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GEOLOGICAL MAP

(back pocket)

Map 2426 (coloured)–Cowie Lake, Algoma District
Scale 1:31 680 (1 inch to ½ mile).

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

ABSTRACT

The report describes the geology, structure, stratigraphy, and mineral deposits of parts of Dablon, Desbiens, Gapp, Gaudry, Lunkie, and Nahwegezhic Townships, an area which covers 256 km² in the District of Algoma. The centre of the map-area is approximately 70 km north-northeast of Sault Ste. Marie.

The area consists of an Early Precambrian metavolcanic-metasedimentary succession that has been overturned, metamorphosed, intruded by granitic rocks, faulted, covered by Huronian Supergroup sedimentary rocks, intruded by diabase dikes, and glaciated during the Pleistocene Epoch.

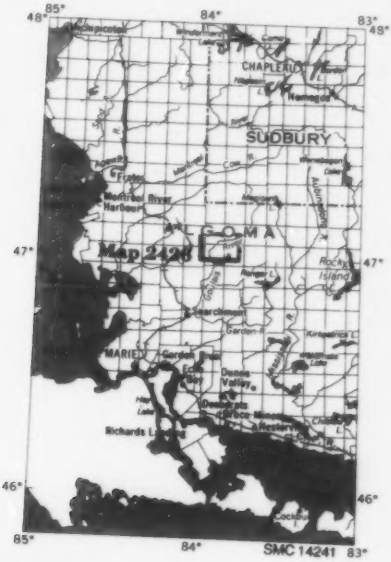


Figure 1–Key map showing location of the Cowie Lake Area.
Scale 1:3 168 000 (1 inch to 50 miles).

The succession is interpreted as being composed of three distinct assemblages with the lowermost mafic to felsic volcanic environment composed of flows and pyroclastic rocks capped by an extensive magnetite-chert iron formation. Overlying this first assemblage is a thick tholeiitic sequence of pillowed mafic to intermediate flows in the northwest that grade southeasterly into felsic to intermediate pyroclastic rocks and flows which have textural characteristics indicating proximity to a calc-alkaline-like volcanic centre. Overlying the second sequence is a clastic metasedimentary sequence derived by the erosion of metavolcanics in the northwest that grade southeasterly into felsic to intermediate metavolcanic tuffs and flows. In the southwestern part of the map-area, alternating mafic to felsic metavolcanics have been interpreted as having emanated from two different sources, one from the northwest, and one from the east.

Metamorphism varies from low grade greenschist facies in the central and northwest parts of the map-area, to hornblende-hornfels facies at the granitic border. Foliation, generally well developed

with submassive schists occurring in the centre of the Batchawana Belt, becomes increasingly schistose and gneissic to migmatitic towards the granitic margin. The predominant foliation strikes N50°W and dips northeast from 45° to vertical. Top determinations show tops are to the south, and indicate overturning of the supracrustal sequence. Deformation was accompanied by the emplacement of granitic plutonic complexes composed of quartz monzonite, granodiorite, and trondhjemite. Syenitic rocks occur locally. Migmatization and assimilation are common in the eastern part of the map-area.

A small outlier of Gowganda Formation conglomerate which has been faulted on the north side was located in the southwest part of the map-area.

Faulting occurred before, or at the same time as the intrusion of a swarm of porphyritic and non-porphyritic diabase dikes, and was followed by the intrusion of olivine diabase dikes.

Economically interesting showings of base metals in the form of sulphides occur in a few places. The Goulais River Iron Range east of Cowie Lake has been explored by the Algoma Steel Corporation Limited. Diamond-drilling and trenching has outlined reserves of approximately 30 million tons of iron ore.

Geology
of the
Cowie Lake Area
District of Algoma

By

E.C. Grunsky[1]

INTRODUCTION

The Cowie Lake Area is bounded by Longitudes 83°45′00″W to 84°00′00″N and Latitudes 47°00′00″N to 47°07′30″N and is approximately 256 km² in area. This area encompasses parts of Gapp, Gaudry, Lunkie, Nahwegezhic, Desbiens, and Dablon Townships. The map-area, shown in Figure 1, was mapped by the author and assistants during the field season of 1977.

Access

Access to the map-area is provided from Highway 556 via Highways 17 or 129 and by road from Mekatina on the Algoma Central Railway. Access from Highway 129 is via Highway 556 that is connected with an excellent gravel road at the Aubinadong River. This gravel road passes northward into the map-area, and is locally known as the Domtar or Ragged Lake road. The distance is approximately 65 km from Highway 129 to Ragged Lake. Access from Highway 17 is via Highway 556 to Searchmont. The Whitman Dam road joins Highway 556 at Searchmont. This road is approximately 56 km in length, and joins Searchmont with Teepee Lake, at which point it connects with the Ragged Lake road. This road is not as well maintained as the Ragged Lake road and is currently being used for hauling lumber. A poorly maintained road exists from Mekatina on the Algoma Central Railway to Hanes Lake. This road is about 16 km in length and joins the Ragged Lake road at the south end of Hanes Lake. It is not well maintained and a four-wheel-drive vehicle may be required in some

[1]Geologist, Precambrian Section, Ontario Geological Survey, Toronto. Manuscript approved for publication by the Chief Geologist, 15th May, 1978. This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

places. Access to the Morrison Lake area is made via the Whitman Dam road from Searchmont. The road forks at kilometre 27, the north route leads to Teepee Lake, and the south route continues for another 20 km into the Morrison Lake area. Access into the southwest corner of the map-area is provided by a very poor road that starts about 7 km from the fork on the Whitman Dam road and goes northward to Teepee Lake. The road is not maintained and is becoming impassable in some places. Float-equipped aircraft can gain access to the map-area into Ragged, Cowie, Chubb, Point, Hanes, Morrison, and Loggers (local name) lakes. The Goulais River provides access into the central and south-central parts of the map-area. However, the river is very shallow in places, and numerous rapids exist necessitating frequent portages.

Mapping Method

The geological map was prepared on a Forest Resource Inventory base-map at a scale of 1:15 840 (1 inch to ¼ mile) by the Cartography Section, Surveys and Mapping Branch, Division of Lands, Ontario Ministry of Natural Resources. Air photographs of the same scale were supplied by the Division of Forests and were used in the field to record the data. The data was recorded on transparent overlays placed on top of the air photographs and the data was then transferred onto the base-map.

Mapping was carried out by traverses that were spaced approximately 0.4 km apart, and in places where detail was essential, this spacing was made closer. Traverses were performed using a pace-and-compass technique. However, the traverse lines were not tied to any survey lines. Some of the outcrops have been interpreted from the air photographs, and their lithology is uncertain. These outcrops are labelled as unsubdivided within their interpreted lithology.

Transportation during the field season was provided primarily by four-wheel-drive truck, and the traverses were performed on foot. Powered canoe and float-equipped aircraft were used as additional means for access.

Acknowledgments

The author was ably assisted in the field by J.T. Arengi, R.M. Cadel, N.I. Corbett, and B.A. Jaffray. Arengi mapped about one half of the area as the senior assistant, and helped the author with interpreting the map units.

During the field season, the field party base camp was located at the Ragged Lake Camp which is managed by the Ontario Ministry of Natural Resources. The author expresses his thanks to Fred Janser of the Timber Division, Ontario Ministry of Natural Resources, Sault Ste. Marie, who arranged the party's stay there.

The author is grateful to Messrs. Giesbrecht and Burgan of HBOG Mining Limited, Jack Huddart of the Algoma Steel Corporation Limited, and to W.L. Oliphant of the Algoma Central Railway, for generously providing the author with information from their companies' files.

The author is also grateful to H.D. Meyn of the Mineral Deposits Section, Ontario Geological Survey, Toronto, who visited the author during the field season, and provided helpful discussions as well as some thin sections and chemical analyses from the Goulais River Iron Range.

Previous Work

The area was first mapped by E.S. Moore (1925) as part of a regional geological survey of the Batchawana Area. E.S. Moore and H.S. Armstrong (1946) remapped the Goulais River Iron Range in detail. Exploration for iron was the main object of economic activity from the early 1900s until the 1960s. During this period the Goulais River Iron Range was examined for the feasibility of extracting iron ore by the Algoma Steel Corporation Limited. In the late 1960s and early 1970s, the area was examined for possible base metals in the form of sulphides. With the exception of the Goulais River Iron Range, the area has not been thoroughly explored.

The map-area is covered by regional compilation maps (L.D. Ayres *et al.* 1971; P.E. Giblin and E.J. Leahy 1967, 1977; J.A. Robertson, P.E. Giblin, and E.J. Leahy 1971; and by E.C. Grunsky and J.T. Arengi 1978). The area that is adjacent to the north has been mapped by G.M. Siragusa (1978 a and b). No detailed geological maps exist adjacent to the area in the east, south, and west. An aeromagnetic survey map of the area is available (ODM-GSC 1963).

Topography and Drainage

The topography of the map-area varies from flat sand plain and hummocky terrain to rugged hills with sparse vegetation. The average elevation in this area is about 460 m above sea level. Relief in the map-area varies from a flat terrain up to 200 m with an average relief of 30 m. The east, southeast, and southwest parts of the map-area have the highest relief, and reflect the presence of the underlying granitic rocks. The northwest and central parts of the map-area are hummocky with many small lakes and swamps and reflect the underlying mafic to intermediate metavolcanics. Sand plains are common in the Goulais River area and extend west of Ragged Lake and southwest from Teepee Lake. Bedrock is well exposed in the Goulais River sand plain and relief can be as great as 60 m. The numerous diabase dikes form ridges that can be traced for several kilometres with a relief as high as 100 m.

Faults, lineaments, and diabase dikes appear to affect the course of the waterways in the map-area. The northwestern part of the map-area drains into the Chippewa River which drains southwestward into the Harmony River. Drainage in this area is poor and in it many swamps and lakes exist along lineaments and topographic depressions which contain accumulations of Recent organic matter and Pleistocene drift. The remainder of the map-area drains into the Goulais River and the area around the river is composed primarily of fluvial gravel, sand, and fine sand. Drainage flows southwestward to Searchmont.

The sides and tops of many of the hills in the south and east parts of the map-area are sparsely vegetated with many small lakes and ponds between them.

The amount of outcrop exposure varies throughout the map-area. In the northwest and central parts, exposure is poor in the low-lying hummocky terrain, and outcrop exposure is generally less than 5 percent. Outcrop exposure east of Hanes Lake, Cowie Lake, and Morrison Lake is highly variable with exposures as great as 70 percent in some areas, particularly in the burned over areas. Southwest of Cowie Lake as far south as the southern boundary of the map-area, exposure varies from 5 to 15 percent.

Natural Resources

The lakes of the map-area vary from the swampy organic-filled ponds that occur in the northwest to deep, clear, rocky lakes such as Morrison and Cowie Lakes. Morrison, Annibal, Cowie, Hanes, Point, Eileen, Chubb, and Red Pine Lakes are accessible by road or a short portage. Many of these lakes are fished by tourists. The lakes contain trout, pike, and pickerel.

Bush fires have occurred in the 1920s, 1930s, and 1940s. The most recent one in 1967 completely burned over the forest cover northeastward from the central part of the map-area, beyond the boundary of the map-area. This burned over area is bounded to the west by Hanes Lake and to the southeast by the Ragged Lake road. Fire damage has been severe in this area and many of the higher hills within the granitic terrain have been completely denuded. Reforestation projects have been under way since this last fire.

Wildlife is more abundant in the northwest, southwest, and southeast parts of the map-area than in the northeast. Moose, bear, fox, beaver, rabbit, and chipmunks were observed infrequently. Black bears were frequently observed in the burned-over area where berries are plentiful.

White pine and yellow birch are the two most common types of commercial wood available in the map-area. White pine exists south and east of Cowie Lake, north and east of Morrison Lake, and westward and southwestward from Hanes Lake to the western boundary of the map-area. Some of these areas have been burned over previously, and the growth is secondary. Logging operations have been carried out in the past around Cowie Lake, Red Pine Lake, and Hanes Lake, and west of Red Pine Lake. Currently, logging operations are being carried out east of Morrison Lake and east of Hanes Lake. Many new roads have been made for the logging operations.

Maple is common in the areas west and south of Cowie Lake and in the southwest part of the map-area. Spruce, cedar, alder, and larch are common in the northwest part of the map-area. Red pine is generally rare, however, the area around Red Pine Lake contains numerous red pine trees.

There are no operating mines, past or present, in the map-area. Numerous gravel pits occur within the Goulais River sand plain and are used for maintaining the roads in the area. Gravel of fairly good quality has been taken from two pits, north of Ragged Lake and west of Cowie Lake. An attractive-looking stone occurs on the Ragged Lake road approximately 1.5 km west of the Ragged Lake

Camp cut off. This rock is an intrusive breccia (agmatite) and is composed of angular, metavolcanic fragments in a medium- to coarse-grained dioritic matrix. Rock colours vary from dark grey to green, and the weathered surface appears to look quite fresh. Occurrences of this rock extend northward to Chubb Lake. This may be an attractive building stone for facing purposes.

Iron and base metals are present within the map-area and are discussed under the heading of "Economic Geology".

GENERAL GEOLOGY

The map-area consists of an Early Precambrian metavolcanic-metasedimentary sequence that has been overturned, intruded by later granitic rocks, metamorphosed, faulted, partly covered by Huronian sedimentary rocks, intruded by diabase dikes, and glaciated. In the absence of age dates for the metavolcanics and metasediments, the age of the Batchawana Belt is believed to be at least 2500 m.y. by inference from the age of the surrounding granitic terrain and age dates of the Abitibi Belt. The surrounding granitic terrain has an age of approximately 2400 m.y., and the diabase dikes have an age of approximately 1035 m.y. (R.K. Wanless 1970).

The map-area is part of the Batchawana Belt lying near the southern edge of the Superior Province of the Canadian Shield. This belt may be a western extension of the Abitibi Belt that lies to the east, but is separated from it by an extensive granitic terrain.

The oldest rocks are a succession of metavolcanics and metasediments that are metamorphic derivatives of basalt, andesite, dacite, rhyolite, flows, pyroclastic breccia, lapillistone, lapilli-tuff, tuff, iron formation, and clastic sedimentary rocks. This succession was subsequently overturned and metamorphosed under regional low grade greenschist facies conditions. This supracrustal sequence was intruded by felsic plutonic rocks which resulted in metasomatism and contact metamorphism of the metavolcanics along the granitic contacts. An outlier of Huronian sedimentary rocks of the Gowganda Formation overlies the Early Precambrian succession with an angular unconformity. Faulting, which post-dated the Huronian sedimentary rocks, was followed by two episodes of mafic intrusive dikes; namely quartz diabase and a later olivine diabase. Glaciation occurred during the Pleistocene Epoch, leaving till, drift, and outwash plains followed by Recent accumulations of organic material in low lying swamp areas and reworking of the outwash plains by Recent drainage systems.

The author has interpreted the metavolcanic-metasedimentary lithologies to be a stratigraphic succession with the youngest rocks exposed in the southwest, and the oldest rocks exposed in the northeast parts of the map-area.

The oldest sequence outcrops in the northern part of the map-area, and extends from a point northwest of Hanes Lake, southeastward to Cowie Lake, and by Annibal Lake. This sequence consists of alternating mafic to intermediate and felsic to intermediate metavolcanic flows and pyroclastic rocks overlain at the top of the sequence by chemical and clastic metasediments. The succession varies in exposed thickness from 1400 m to 2200 m. This variation may be partly due to changing dip attitudes of the overturned units. The second sequence con-

TABLE 1 TABLE OF LITHOLOGIC UNITS OF THE COWIE LAKE AREA

PHANEROZOIC
- CENOZOIC
  - QUATERNARY
    - PLEISTOCENE AND RECENT
      - Fluvial gravel, sand, silt, clay, and swamp deposits

Unconformity

PRECAMBRIAN
- LATE PRECAMBRIAN
  - MAFIC INTRUSIVE ROCKS
    - Porphyritic and non-porphyritic quartz diabase, olivine diabase
- MIDDLE PRECAMBRIAN
  - HURONIAN SUPERGROUP
    - COBALT GROUP
      - GOWGANDA FORMATION
        - Paraconglomerate, orthoconglomerate, arkose, greywacke, siltstone

Angular Unconformity

- EARLY PRECAMBRIAN
  - FELSIC INTRUSIVE ROCKS
    - Migmatite, tonalite, diorite, quartz monzonite, granodiorite, trondhjemite, syenite, nepheline syenite, syenodiorite, aplite dikes and veins

Intrusive Contact

  - METAVOLCANICS AND METASEDIMENTS
    - METASEDIMENTS
      - CLASTIC METASEDIMENTS
        - Quartz-plagioclase-biotite schist, gneiss, sandstone, arkose, greywacke, siltstone, chert, cherty siltstone, gritty sandstone, conglomeratic sandstone, conglomerate
      - IRON FORMATION
        - Magnetite-chert, pyrite-chert
    - METAVOLCANICS
      - FELSIC TO INTERMEDIATE METAVOLCANICS
        - Quartz-plagioclase-muscovite-hornblende schist, gneiss, massive to foliated flows, pyroclastic breccia, lapillistone, lapilli-tuff, tuff
      - MAFIC TO INTERMEDIATE METAVOLCANICS
        - Fine-grained hornblende-chlorite schist gneiss, amphibolite, medium to coarse-grained flows, pillowed flows, migmatite

sists of a very thick sequence of mafic to intermediate metavolcanic flows having an exposed thickness of 6000 m that appears to be subaqueous in origin. This sequence extends southwestward of Hanes Lake to the western boundary of the map-area where it is overlain by a metasedimentary sequence. Southeastward of Hanes Lake, the mafic to intermediate metavolcanics grade into felsic to intermediate metavolcanics in the Goulais River area. The Goulais River area con-

sists of alternating flows and pyroclastic rocks, and appears to represent an area of transitional change from a predominantly mafic volcanic environment to a felsic volcanic environment. Evidence from the coarse pyroclastic rocks and the mafic to intermediate flows suggests that a volcanic centre was located nearby. Southeast of the Teepee Lake-Goulais River area, the rocks are composed of felsic to intermediate metavolcanic flows and pyroclastic rocks which overlie the chemical metasediments of the Goulais River Iron Range and the clastic metasediments north of Morrison Lake. This sequence of felsic volcanic rocks extends southwestward to the southwest corner of the map-area, and has an exposed thickness of approximately 9600 m. Southwest and west of Private Lake, the felsic to intermediate metavolcanics become predominantly tuffaceous, and in the western part of the map-area grade northwesterly into clastic metasediments. The clastic metasediments in the west represent the start of the third stratigraphic sequence, and are believed by the author to be derived from weathering of the underlying volcanic rocks exposed to the northwest. The metasediments grade into the felsic metavolcanic tuffs to the southeast. These metasediments are approximately 1200 m in exposed thickness. The metasediments are overlain by another sequence of mafic to intermediate flows 1000 m thick that in turn are overlain by a sequence of felsic metavolcanic tuff and lapilli-tuff. The latter sequence is part of the felsic metavolcanics to the southeast. In the southwestern corner of the map-area, a thin (400 m) mafic to intermediate sequence of flows is overlain by felsic metavolcanic pyroclastic rocks which have been intruded by the granitic rocks.

Compositional variations within the metavolcanic assemblage have suggested the author to believe that the source and type of volcanism can be related to the above stratigraphic model. This is discussed in the section "Petrochemistry and Stratigraphic Synthesis of the Cowie Lake Area".

Precambrian

EARLY PRECAMBRIAN

Metavolcanics and Metasediments

METAVOLCANICS

Mafic to Intermediate Metavolcanics

Mafic to intermediate metavolcanics occur in four distinct localities:

1) The northwest to central part of the map-area;
2) East of Cowie Lake;
3) In the Hanes Lake area;

TABLE 2 | CHEMICAL ANALYSES OF MAFIC TO INTERMEDIATE METAVOLCANICS OF THE COWIE LAKE AREA
CHEMICAL ANALYSES BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY

Major Components in Weight Percent

Sample Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	27	28
SiO_2	48.10	46.60	49.80	48.80	49.20	53.10	50.10	53.20	52.70	54.50	48.70	59.70	53.20	63.00	61.00	50.30	64.80
Al_2O_3	15.90	14.90	13.30	16.00	15.50	14.30	15.20	13.50	12.80	16.10	10.30	13.70	15.30	16.60	16.60	14.10	15.30
Fe_2O_3	13.10	13.20	15.80	12.50	14.50	10.10	12.90	11.90	13.90	8.62	11.20	6.88	11.20	5.51	6.97	15.38	5.41
MgO	5.19	7.02	5.65	7.85	5.07	6.51	5.12	4.98	4.71	4.69	12.00	4.16	5.18	3.05	2.30	6.56	2.44
CaO	11.40	7.17	9.10	10.60	6.08	8.06	8.05	7.67	6.66	7.52	7.65	5.47	4.92	3.05	5.80	7.70	4.44
Na_2O	3.25	2.63	1.42	2.10	2.79	4.94	1.85	3.83	3.99	4.81	0.00	3.99	4.27	4.54	4.88	2.51	2.64
K_2O	0.20	0.00	0.16	0.40	0.03	0.05	0.07	0.13	1.81	0.02	0.23	1.30	0.00	1.05	0.66	0.50	3.56
TiO_2	1.21	1.24	1.51	0.90	1.31	1.16	1.09	1.54	1.47	0.89	0.61	0.71	0.98	0.92	0.91	2.20	0.88
P_2O_5	0.08	0.08	0.09	0.05	0.06	0.08	0.06	0.11	0.15	0.05	0.03	0.14	0.04	0.31	0.29	0.23	0.19
MnO	0.23	0.18	0.27	0.20	0.31	0.22	0.29	0.23	0.22	0.20	0.22	0.11	0.22	0.08	0.19	0.15	0.08
L O I	1.10	8.10	3.20	0.80	4.70	1.40	5.40	2.40	1.70	2.50	9.70	2.10	4.70	2.10	1.10	1.96	1.52
Total	99.8	101.1	100.3	100.4	99.5	99.9	100.1	99.5	100.1	99.9	100.6	98.3	100.0	100.2	100.7	100.2	100.6

Molecular Norms

Apatite	0.173	0.184	0.204	0.107	0.137	0.170	0.137	0.242	0.326	0.107	0.070	0.307	0.089	0.663	0.614	0.500	0.407
Pyrrhotite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.072	0.035
Ilmenite	1.744	1.894	2.273	1.279	1.986	1.636	1.660	2.254	2.129	1.272	0.953	1.035	1.447	1.309	1.281	3.181	0.826
Orthoclase	1.224	0.0	1.022	2.414	0.193	0.299	0.453	0.808	11.128	0.121	1.525	8.042	0.0	6.344	3.944	3.069	21.518
Albite	30.182	25.884	13.774	19.239	27.263	44.895	18.156	36.134	37.236	44.303	0.0	37.468	40.624	41.639	44.272	23.386	24.233
Anorthite	29.185	31.636	31.819	33.733	32.315	16.909	36.043	20.247	12.131	22.867	30.751	16.352	23.937	13.387	21.672	26.708	19.805
Corundum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.561	0.0	0.0	0.0
Magnetite	2.931	3.140	3.400	2.560	3.198	2.815	2.960	3.340	3.228	2.563	2.453	2.417	2.748	2.585	2.546	1.736	1.635
Hematite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enstatite	0.692	19.525	13.415	13.072	15.215	7.434	13.865	9.742	8.818	9.181	33.634	8.758	14.754	8.601	5.029	16.319	6.510
Ferrosilite	0.544	11.310	12.085	6.917	14.130	2.997	11.284	5.986	7.774	4.320	10.860	3.167	9.706	1.496	2.936	13.693	3.501
Quartz	0.0	0.995	8.945	0.0	5.488	0.0	9.690	6.054	0.0	3.20	10.468	13.593	5.372	20.414	13.312	2.233	20.388
Diopside	12.890	3.440	6.872	10.787	0.039	13.138	3.172	9.410	9.013	8.203	7.005	6.508	0.799	0.0	2.773	4.950	0.749
Forsterite	5.763	0.0	0.0	2.736	0.0	3.142	0.0	0.0	0.143	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fayalite	4.533	0.0	0.0	1.448	0.0	1.267	0.0	0.0	0.126	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hedenbergite	10.139	1.993	6.191	5.707	0.036	5.298	2.581	5.782	7.946	3.860	2.262	2.354	0.525	0.0	1.619	4.154	0.403
Normative Plagioclase	49.16	55.00	69.79	63.68	54.24	27.36	66.50	35.91	24.57	34.04	100.0	30.38	37.08	24.33	32.86	53.32	44.98
Molecular Colour Index	39.24	41.30	44.24	44.51	34.60	37.73	35.52	36.51	39.18	29.40	57.19	24.24	29.98	13.99	16.19	44.03	13.62

Notes:

1. G-51-381 — Alkali basalt · fine-grained flow.
2. G-51-380 — Tholeiitic basalt · fine-grained flow.
3. G-51-379 — Tholeiitic basalt · pillowed flow.
4. G-49-376 — Tholeiitic basalt · fine-grained flow.
5. G-14-159 — Calc-alkaline basalt · fine-grained flow.
6. G-10-124 — Calc-alkaline andesite · fine-grained flow.
7. G-7-90 — Tholeiitic basalt · fine-grained flow.
8. G-4-53 — Tholeiitic basalt · fine-grained flow.
9. G-1-4 — Calc-alkaline andesite · fine-grained flow.
10. G-14-160 — Calc-alkaline andesite · fine-grained flow.
11. 6-8-118 — Tholeiitic basalt · fine-grained flow.
12. G-2-22 — Calc-alkaline andesite · fine-grained flow-amphibolitic.
13. A-4-67 — Calc-alkaline andesite · fine-grained flow.
14. G-45-359 — Calc-alkaline dacite · fine-grained flow.
15. G-43-344 — Calc-alkaline andesite · fine-grained flow.
27. M-77-126 — Tholeiitic basalt · amphibolite.
28. M-77-133 — Calc-alkaline andesite · fine-grained flow.

Rock classification after Irvine & Baragar (1971).

Abbreviation:

L O I — Loss on ignition

4) The southwest part of the map-area.

Compositionally, these rocks are composed of tholeiitic basalt, calc-alkalic andesite and basalt, and minor amounts of komatiitic basalt. Tholeiitic basalt is the most abundant mafic metavolcanic rock in the map-area. Chemical analyses of the mafic to intermediate metavolcanics are shown in Table 2 and compositional trends are shown in Figures 2 and 3. Chemical analyses indicate the presence of an alkali basalt, but this may be due to alteration effects and lies close to the sub-alkaline field of SiO_2 vs $Na_2O + K_2O$ (Irvine and Baragar 1971). The location of samples taken for chemical analyses are marked on the map (Map 2426, back pocket).

The mafic to intermediate metavolcanics in the central and northwest part of the map-area consist of pillowed flows of undetermined thickness that are predominantly tholeiitic in composition. Southeastward, these rocks are calc-alkalic andesite and dacite. East of Cowie Lake and in the southwest parts of the map-area, the pillowed mafic to intermediate metavolcanics have been extensively recrystallized to fine-grained amphibolite. Outcrop is generally poor in the northwest and central parts of the map-area and is usually less than 5 percent.

The most common mafic to intermediate metavolcanics encountered in the field are fine-grained submassive to schistose hornblende-chlorite schists that represent volcanic flows. In areas where outcrop density is poor, flow thicknesses or contacts were not observed and could not be measured. These schists vary from dark green-grey to light green-grey-brown on the weathered surface and from dark grey green to black on the fresh surface. The texture varies from submassive poorly foliated units as in the northwest and central parts of the map-area to amphibolitic schist and gneiss near the margins of the belt. In thin section, these rocks are composed of fine-grained plagioclase, chlorite, hornblende, saussurite, sericite, uralite, actinolite, carbonate, opaque minerals, and a fine-grained indescernible groundmass.

The schists that occur near the margin of the felsic intrusive rocks are generally granoblastic. Recrystallization has produced a mineralogy essentially composed of plagioclase, hornblende, and epidote. In the fine-grained submassive units, plagioclase microlites and microlitic pseudomorphs composed of saussurite and sericite occur in a highly altered submicroscopic groundmass with grains of chlorite, uralite, and occasional hornblende. Compositions of plagioclase could not be determined due to the extensive breakdown of the microlites into saussurite and sericite. Tables 2 and 3 list normative plagioclase compositions (Irvine and Baragar 1971) which have been determined from chemical analyses.

Modal analyses of selected rocks (see Table 5), contain one sample selected from this unit. In many of these rocks metamorphism has altered the fine-grained texture to such an extent that only a faint outline of the microlites is preserved. The microlites vary from 0.1 mm to 1.0 mm in length, and commonly display glomeroporphyritic, swallow tail, and pilotaxitic textures. Opaque minerals, usually pyrite, pyrrhotite, or magnetite, vary in amount but usually constitute less than 2 percent of the rock. They are usually subhedral to euhedral in form and most commonly occur as tiny grains dispersed within the groundmass. Due to alteration, plagioclase rarely exceeds 30 percent of the rock, and where alteration is extensive, saussurite and sericite occur in amounts up to 40 percent. Carbonate is a common secondary mineral, and is partly the result of the alteration of plagioclase associated with low grade metamorphism. Epidote is a com-

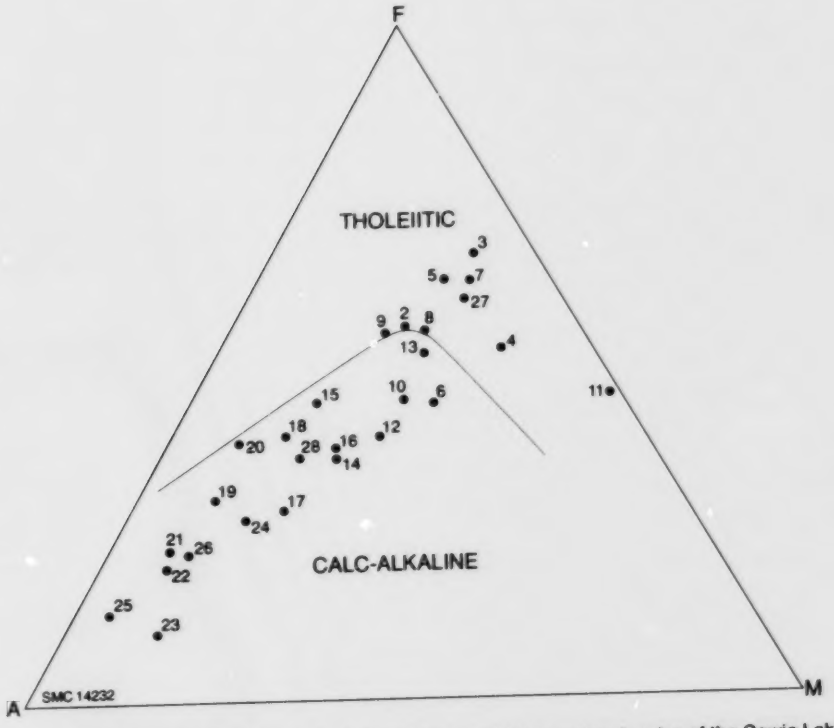


Figure 2–AFM Ternary plot of the mafic, intermediate, and felsic metavolcanics of the Cowie Lake Area.

mon constituent in many of the metavolcanics that have a well-developed schistosity, and has developed from altered plagioclase. Uralite, actinolite, and hornblende are common in the units that have experienced higher grade metamorphism. Hornblende and actinolite occur in poikiloblastic forms in these rocks, and hornblende is also commonly porphyroblastic in the schists and gneisses near the margins of the felsic intrusive rocks. Quartz is a common constituent in many of the rocks, is of secondary origin, and occurs as fracture fillings.

Mafic to intermediate flows were mapped using the following field observations:

1) Pillowed outlines;
2) Flow contacts;
3) Grain size variation within the flow units;
4) Flow breccias;
5) Amygdules/vesicles;
6) Flow tops;

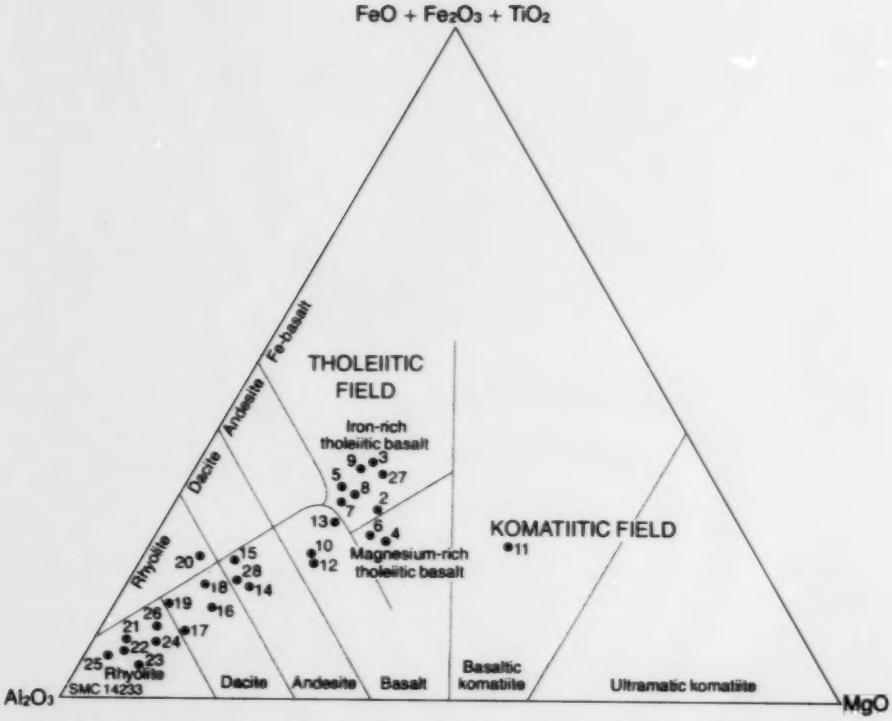


Figure 3–Jensen Cation Plot of the mafic, intermediate, and felsic metavolcanics of the Cowie Lake Area.

7) Porphyritic flows;

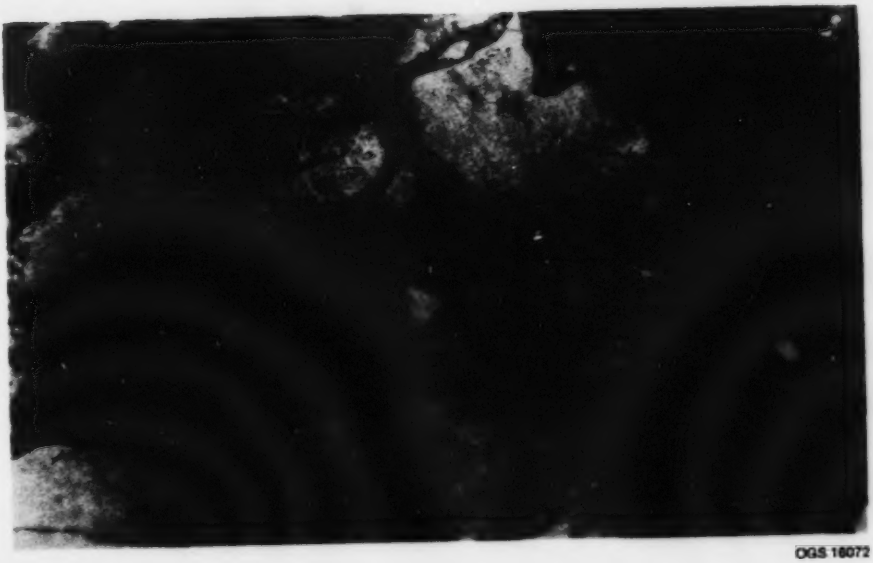
8) Colour index greater than 30.

Pillowed flows are particularly common in the northwest and north central part of the map-area (Photos 1 and 2). In thin section the texture and mineralogy is identical to that of the fine-grained submassive to schistose chlorite-hornblende schist (Photo 3).

In the northwest and central parts of the map-area flow thicknesses could not be measured. However, east of Cowie Lake and in the area west of Chubb Lake, pillowed flow units are 1 to 10 m thick. In the amphibolites, west of Chubb Lake, east of Cowie Lake, and in migmatitic amphibolite southeast of Annibal Lake, pillow outlines were the only macroscopic features that were recognized in these flows. Pillows vary in size from 0.5 m to 2.0 m in the long dimension and 0.25 to 0.5 in the short dimension. Generally, the pillows have been stretched parallel to the regional foliation of N50°W and in many places, the stretching has been severe enough (as great as 10:1) to prevent top determinations. The selvages are chloritic and are generally 1 to 2 cm wide and always

OGS 16071

Photo 1–Pillowed mafic to intermediate metavolcanic flow on the Ragged Lake Road, west of Hanes Lake.



OGS 16072

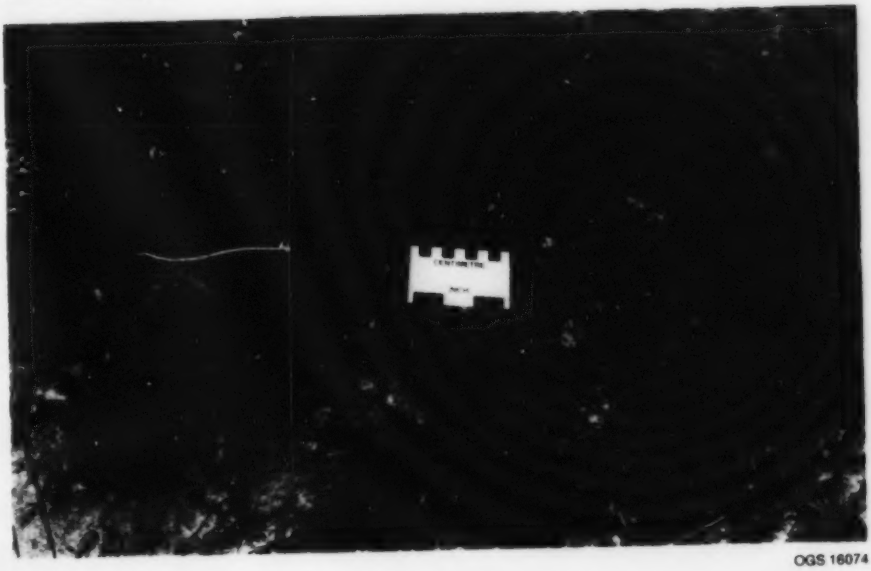
Photo 2–Pillow breccia in mafic to intermediate metavolcanic flow 1.5 km southeast of Hanes Lake on the Ragged Lake Road.

OGS 16073

Photo 3–Photomicrograph of microlitic mafic metavolcanic flow 1.5 km northeast of Forrester Lake. Plane light, field of view is 6 mm.

weather darker than the cores. The pillows are generally uniform in colour and texture, being light grey green on the weathered surface and dark grey to black on the fresh surface. Some outcrops exhibit concentric banding within the pillows. In the margins of the pillows are amygdules and variolites commonly less than 3 mm in the maximum dimension. This was exhibited in some flows and pillows. Excellent exposures can be observed on the Ragged Lake road west and south of Hanes Lake and on the road leading to Mekatina between Hanes Lake and Red Pine Lake.

Amygdaloidal flows are commonly chert filled. Porphyritic flows contain plagioclase phenocrysts up to 1 cm across. Flows exhibiting sheared tops, varioles, vesicles, and amygdules (Photo 4), contacts, and grain size gradation were observed in the Goulais River area southwest of Teepee Lake. Exposure in this area is excellent; as great as 60 percent. Flow thicknesses were easily measured and many features that were not observed elsewhere in the map-area were observed here. Sheared flow tops and grain size gradation from coarse-grained bottoms to fine-grained tops were commonly noted in flows varying from 1 to 20 m in thickness interbedded with felsic to intermediate pyroclastic rocks and flows. This particular area is part of a transition zone in which the felsic and mafic metavolcanics are interbedded; these rocks originated from possibly one or more sources. In thin section, the mafic to intermediate flows are similar in mineralogy to foliated chlorite-hornblende schist. However, texturally these rocks are somewhat different. Many of the flows in this area are coarser grained and the ferromagnesian minerals have subsequently been replaced by uralite, actinolite,



OGS 16074

Photo 4–Amygdaloidal mafic metavolcanic flow in the Goulais River Area, 2.4 km southwest of Teepee Lake.

and hornblende. The foliation is strongly developed in the Goulais River area; examination of thin sections of rock samples of this area often reveal intense shearing.

Porphyritic flows were observed in the Goulais River area, east of Cowie Lake and east of Watson Lake. Phenocrysts vary in size from 1 mm to 1 cm, and consist of plagioclase.

Mafic to intermediate tuffs were noted in the Goulais River area and in the lowermost sequence of metavolcanics west of Chubb Lake. The tuffs can be recognized by the following; distinct to indistinct clast boundaries, their strongly developed schistosity, and a matrix that is chloritic to amphibolitic in composition. Pyroclasts, usually of lapilli size, are generally more felsic in composition than the matrix. Tuffaceous units are very thin, from less than 1 cm to 1 m in thickness. In thin section, these rocks are composed of fine-grained chlorite, hornblende, epidote, plagioclase, saussurite, and minor amounts of quartz. The texture is generally granoblastic, and the schistosity is defined by the chlorite or hornblende.

Migmatitic mafic to intermediate metavolcanics are common along the east margin of the Batchawana Belt and in the mafic to intermediate sequence in the southwest corner of the map-area. The paleosome is composed of gneissic to schistose amphibolite in which relict flow features were occasionally preserved. Southeast of Annibal Lake, pillowed structures were observed in these rocks. The neosome is principally coarse-grained leucocratic quartz-feldspar injections which are parallel to and obliquely cross cut the foliation.

Felsic to Intermediate Metavolcanics

Felsic to intermediate metavolcanics occur in the Hanes Lake area and in a very extensive succession extending from Cowie Lake southwestward to the southern boundary of the map-area. These two areas are stratigraphically distinct; in the Hanes Lake area, the succession underlies that southwest of Cowie Lake and the two are separated by mafic flows and the Goulais River iron formation. The felsic to intermediate metavolcanics consist of flows, pyroclastic breccia, lapillistone, lapilli-tuff, and ash tuff. Chemical analyses of selected samples are shown in Table 3. Figures 2 and 3 indicate that the composition of these samples varies from calc-alkaline andesite to rhyolite with dacite being the most common metavolcanic rock.

The felsic to intermediate metavolcanics in the Hanes Lake area consist of felsic to intermediate pyroclastic breccia, lapilli-tuff, and ash tuff. The tuffs are fine-grained, recrystallized, and schistose, and vary from dark grey to light grey-buff on fresh and weathered surfaces. Texturally, the rocks vary from schist to migmatite. Migmatitic felsic to intermediate metavolcanics are common east of Point Lake and northeast of Hanes Lake and contain a quartzofeldspathic neosome which is parallel and subparallel to the foliation.

Felsic to intermediate metavolcanics east and southwest of Cowie Lake represent a continuous stratigraphic succession of flows, pyroclastic breccia, lapillistone, and crystal and ash tuff. These units are submassive to schistose, and have not undergone as extreme an amount of recrystallization west of Cowie Lake, as have the units in the Hanes Lake area and east of Cowie Lake.

Most of the felsic to intermediate metavolcanic flows and tuffs have been altered and deformed by low grade metamorphism and by the development of foliation. As a result, very few primary textures are preserved in the flows and fine-grained tuff. These altered rocks were mapped as fine-grained quartz-plagioclase-muscovite-hornblende-schist[1], gneiss, and migmatite. The colour varies from light grey to light buff on both the fresh and weathered surfaces, and the colour index varies from 5 to 30. The schistosity is usually well developed because of the alignment of platy minerals such as muscovite. Bedding is generally indistinct and was observed only where compositional changes were visible. Plagioclase is almost always altered to sericite and saussurite. In higher metamorphic grades, epidote, muscovite, and hornblende have developed. Some of these schists may be metasedimentary, particularly in the southwest-central part of the map-area where the metasediments from the west grade into the felsic schists along the strike of the units. These schists comprise a very thick monotonous sequence that was volcanic in origin, and may have subsequently been reworked and redeposited as sedimentary rocks.

Thin section examination of these schists (modal analyses, see Table 5) reveals a fine-grained groundmass of sub-granoblastic quartz and plagioclase (albite to oligoclase) with zoned and twinned crystals of plagioclase in some of the sections. Due to the obliteration of primary features by shearing and metamor-

[1]Map code 2a (Map 2426, back pocket) should read quartz-plagioclase-muscovite-hornblende-schist gneiss.

TABLE 3 | CHEMICAL ANALYSES OF FELSIC TO INTERMEDIATE METAVOLCANICS OF THE COWIE LAKE AREA. CHEMICAL ANALYSES BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Major Components in Weight Percent

Sample Number	16	17	18	19	20	21	22	23	24	25	26
SiO_2	68.50	70.90	64.90	67.50	66.10	73.60	72.80	74.00	73.90	71.30	68.60
Al_2O_3	14.50	16.30	16.20	16.10	14.30	15.30	15.60	14.90	13.20	14.20	15.40
Fe_2O_3	3.73	2.82	5.21	3.61	5.57	2.00	1.70	1.07	1.93	1.34	2.39
MgO	1.97	1.69	1.77	1.05	1.12	0.61	0.66	1.06	1.01	0.37	0.95
CaO	4.07	0.83	4.45	1.74	3.19	2.85	2.07	0,56	2.56	2.44	3.73
Na_2O	0.91	1.18	3.63	3.69	3.62	3.81	2.76	3.67	0.28	5.26	4.96
K_2O	2.75	3.36	1.76	2.64	3.09	1.63	2.62	3.44	3.38	1.92	1.44
TiO_2	0.43	0.37	0.65	0.70	0.96	0.27	0.26	0.15	0.12	0.22	0.70
P_2O_5	0.07	0.05	0.14	0.13	0.29	0.05	0.04	0.01	0.01	0.03	0.16
MnO	0.08	0.04	0.07	0.10	0.09	0.04	0.04	0.03	0.05	0.04	0.04
L.O.I.	3.20	2.50	1.40	2.00	1.40	0.70	1.30	1.40	4.20	2.50	1.10
Total	100.2	100.0	100.2	99.3	99.7	100.9	99.8	100.3	100.6	99.6	99.5

Molecular Norms

Apatite	0.156	0.110	0.301	0.283	0.629	0.106	0.086	0.021	0.023	0.065	0.341
Pyrrhotite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ilmenite	0.638	0.543	0.929	1.014	1.385	0.380	0.065	0.048	0.180	0.064	0.333
Orthoclase	17.315	20.917	10.676	16.230	18.929	9.742	15.991	20.684	21.549	11.667	8.666
Albite	8.697	11.151	33.425	34.436	33.662	34.565	25.570	33.497	2.710	48.520	45.310
Anorthite	21.012	3.990	21.707	8.090	14.128	13.959	10.329	2.758	13.623	9.725	15.778
Corundum	3.244	10.720	0.636	4.901	0.0	2.433	5.130	4.597	5.233	0.0	0.0
Magnetite	2.148	1.376	2.305	1.789	2.664	0.011	0.0	0.0	0.555	0.0	0.0
Hematite	0.0	0.454	0.0	0.401	0.0	1.239	1.223	0.758	0.847	0.960	1.560
Enstatite	5.790	4.911	5.011	3.013	3.120	1.702	1.880	2.975	3.006	0.044	1.873
Ferrosilite	0.735	0.0	2.022	0.0	1.438	0.0	0.0	0.0	0.0	0.0	0.0
Quartz	40.265	45.827	22.989	29.843	23.805	35.864	39.571	34.578	52.274	26.819	24.219
Diopside	0.0	0.0	0.0	0.0	0.165	0.0	0.0	0.0	0.0	2.010	1.591
Hedenbergite	0.0	0.0	0.0	0.0	0.076	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.0	0.0	0.0	0.0	0.0	0.0	0.154	0.082	0.0	0.125	0.329

Table 3 continued

Normative Plagioclase Composition	70.72	26.35	39.37	19.02	29.56	28.77	28.77	7.61	83.41	16.70	25.83
Molecular Colour Index	9.31	7.28	10.27	6.22	8.85	3.33	3.17	3.78	4.59	3.08	5.36

Notes:

16. G-51-385 — Calc-alkaline dacite flow.
17. G-51-384 — Calc-alkaline dacite flow.
18. G-49-375 — Calc-alkaline andesite schist.
19. G-20-208 — Calc-alkaline dacite - felsic metavolcanic schist.
20. G-2-38 — Calc-alkaline dacite - felsic lapilli-tuff.
21. G-44-352 — Calc-alkaline dacite - felsic metavolcanic schist.
22. G-51-383 — Calc-alkaline dacite flow.
23. G-51-382 — Calc-alkaline rhyolite - banded flow.
24. G-46-363 — Calc-alkaline rhyolite* - flow.
25. G-15-170 — Calc-alkaline rhyolite - felsic metavolcanic schist.
26. G-2-39 — Calc-alkaline dacite - felsic metavolcanic schist.

Classification after Irvine & Baragar (1971).
*Actual classification by Irvine & Baragar is a tholeiitic basalt, due to an anomalously low Na_2O concentration.
Classification by Jensen (1976) is a calc-alkaline rhyolite.

phism, the nature of most of these schists is uncertain. Due to their fine-grained nature, and occasional, units of interbedded lapilli-tuff, the author believes that these schists may be tuffaceous in origin, particularly in the southwest-central part of the map-area.

The felsic to intermediate metavolcanic flows are light grey-buff to cream coloured units that were most commonly observed in the area west of Cowie Lake and southwest of Teepee Lake. These rocks are commonly interbedded with the mafic flows in the central part of the map-area. Flow thickness varies from 1 to 30 m. Porphyritic textures are common. Plagioclase and quartz are the common phenocrysts. In thin section, these rocks are seen to consist of quartz, plagioclase, saussurite, sericite, muscovite, chlorite, and hornblende. Quartz, plagioclase, and muscovite are the dominant minerals in the matrix with chlorite and hornblende occurring sporadically throughout. Hornblende is common as poikiloblasts and porphyroblasts in the felsic flows and in schists of higher metamorphic grade.

The pyroclastic metavolcanics comprise pyroclastic breccia, lapillistone, lapilli-tuff, crystal tuff, and ash tuff (classification after Fisher 1966). Compositionally the pyroclastic rocks are of three types: i) felsic pyroclasts in a felsic matrix; ii) mafic to intermediate pyroclasts in a felsic matrix; and iii) felsic pyroclasts in an intermediate to mafic matrix.

Fine-grained tuffs are common in the area west of Point Lake, and east of Private Lake. These rocks are usually light grey-brown to cream coloured on the weathered surface and light grey-brown to light buff on the fresh surface. Schistosity is usually well developed. Rhyolitic flows displaying a finely banded flow texture were observed in the Teepee Lake area (Photo 5). Thin section examination shows that the rocks are composed of quartz, plagioclase, muscovite, sericite, and chlorite. Hornblende is common in the tuffs of higher metamorphic grade in the Point Lake, Chubb Lake, and Cowie Lake area. The tuff is very similar to the schist of undetermined origin discussed previously. The distinction between the two has been based on the presence of clasts observed in outcrop and thin section.

Crystal tuff is more common in the Hanes Lake area. The matrix is composed of fine-grained quartz, plagioclase, muscovite, and minor chlorite, displaying sub-granoblastic textures. The crystal fragments are commonly composed of angular and fractured plagioclase, quartz, and occasionally microcline. Crystal sizes vary from 0.1 to 1.0 mm across.

Lapilli-tuff is abundant in the felsic to intermediate metavolcanics throughout the map-area. Generally, the matrix is composed of fine- to medium-grained quartz, plagioclase, muscovite, chlorite, hornblende, biotite, and epidote, the amount of each mineral depends on the composition. Schistosity is usually well developed in the matrix, although the lapilli may often be submassive except in the areas of higher grade metamorphism. The matrix is usually more mafic than the fragments. The pyroclasts vary in shape from subrounded to angular, and are often highly lineated up to 20:1. West of Chubb Lake, some of the lapilli are subrounded and equant on the surface, but highly stretched in the vertical direction, imparting a strong lineation. The fragments are composed of fine-grained sub-granoblastic to granoblastic quartz, plagioclase, and muscovite. Crystal fragments were commonly observed in pyroclasts of the matrix. Southwest of Tee-

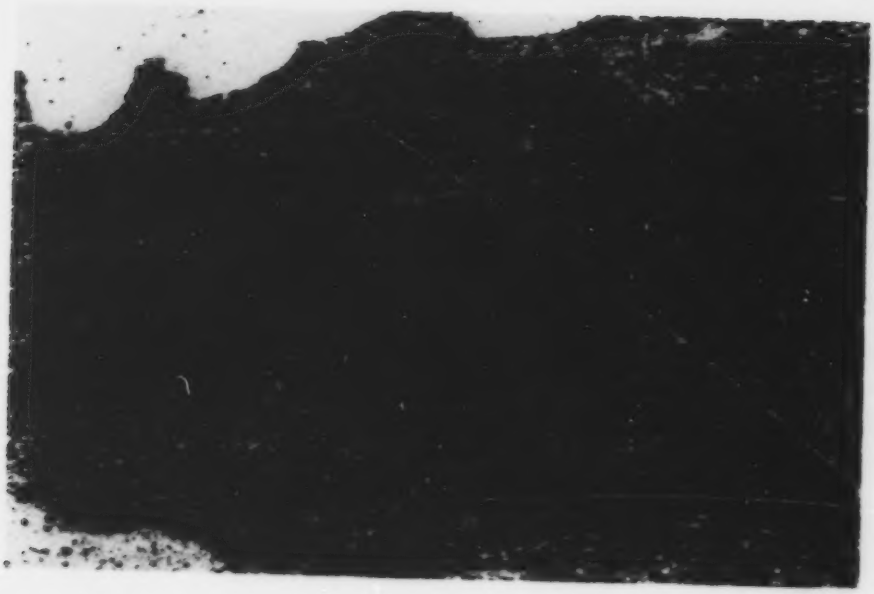


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Photo 5–Photomicrograph of a rhyolite flow 200 m north of Teepee Lake on the Searchmont Road. Note the banding in the flow. Plane light, field of view is 6 mm.

pee Lake, chilled margins and vesicles were observed in the less recrystallized tuffs.

Lapillistone and pyroclastic breccia are restricted to two areas which are southwest of Teepee Lake and east of Hanes Lake. These rocks are composed of angular and fractured felsic to intermediate metavolcanic clasts in crystal and ash tuff of intermediate and felsic composition. Fragment size and shape vary from subrounded to angular lapilli to large blocks and bombs up to 1.0 m across. These units do not show any stratification and commonly occur as lenses that grade along strike from breccia to tuff. Photos 6 and 7 show two types of breccia that were observed in the Goulais River area southwest of Teepee Lake. The blocks and bombs commonly exhibit vesicular features and chilled margins. These breccias are commonly interbedded with mafic to intermediate flows, and they may represent pyroclastic debris that accumulates on the flanks of a volcanic centre. The matrix to fragment ratio varies from a completely clast-supported breccia (matrix less than 10 percent; Photo 7) to breccia in which the matrix makes up to 60 percent of the rock. Pyroclastic breccia in the Hanes Lake area is not as well exposed as in the Goulais River area. Higher grade metamorphism has obliterated many primary textures, and the margins of the fragments are often recrystallized and less distinct.

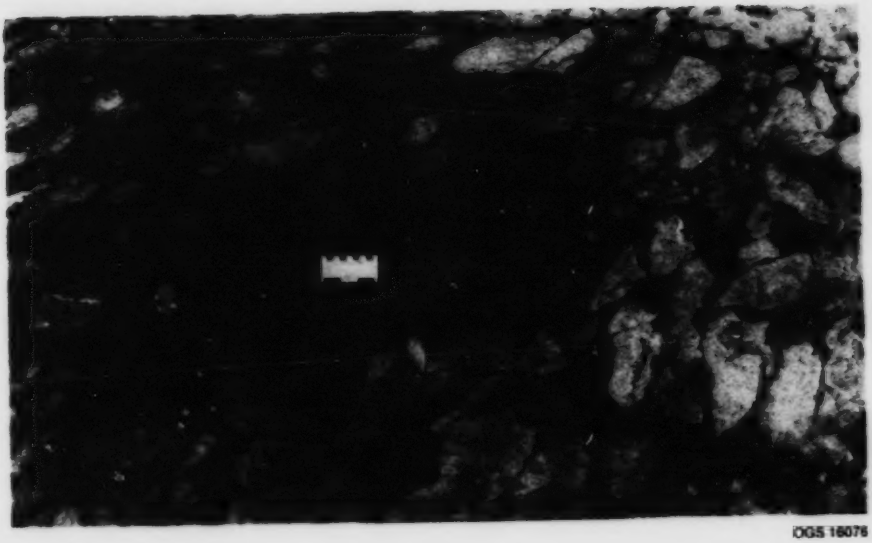

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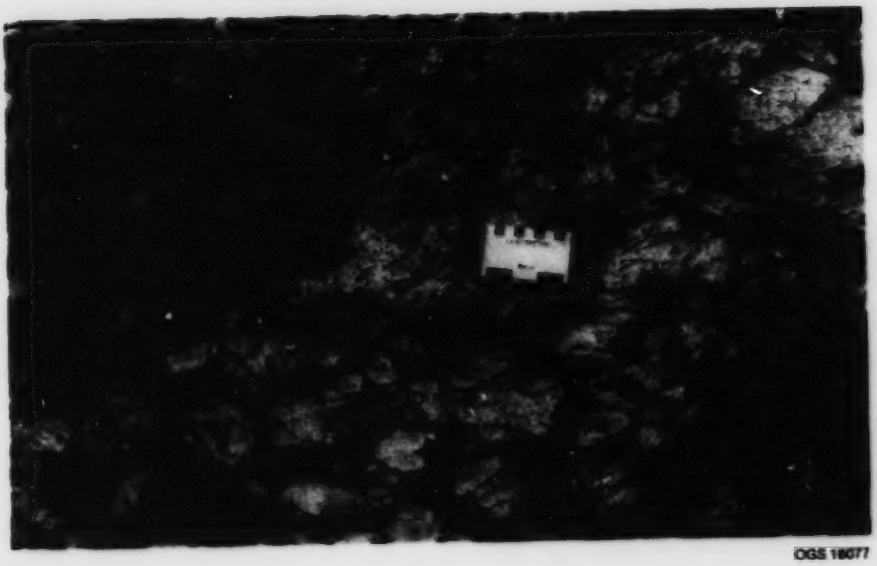
Photo 6–Pyroclastic breccia with an intermediate crystal and ash tuff matrix, 1.2 km west of Teepee Lake.



OGS 16077

Photo 7–Clast-supported felsic pyroclastic breccia 4.0 km west of Cowie Lake near the Goulais River.

METASEDIMENTS

Iron Formation

Iron formation in the form of magnetite chert (oxide facies, Gross 1965) and pyrite chert (sulphide facies) is common, and generally forms thinly bedded interflow units within the map-area. An exception to this is the Goulais River Iron Range east of Cowie Lake in which a large accumulation of oxide facies iron formation exists.

The magnetite iron formation is usually associated with the felsic to intermediate metavolcanics, and is interbedded with tuff, chert, and siltstone. The magnetite-chert laminae vary from 0.15 to 0.65 mm in thickness, and the units are usually less than 2 m thick. The chert is commonly recrystallized and granular in appearance due to metamorphism and shearing. The iron formation cannot usually be traced very far along strike (less than 1 km), and appears to represent chemical accumulations in shallow basins subsequently capped by volcanic effusions.

Sulphide iron formations occur throughout the map-area in both the felsic and mafic metavolcanic flows and pyroclastic rocks. In terms of frequency of occurrence, sulphide facies iron formation is more common than the oxide facies iron formations, but does not form extensive deposits. Some of the units may be exhalative in origin. The pyrite varies from fine to coarse grained, and occurs as laminae interbedded with fine- to medium-grained chert. Frequently, the coarse-grained units represent recrystallization due to metamorphism. The laminae vary from 1.0 mm to 1.0 cm in thickness, and average about 20 to 3.0 mm.

The sulphide iron formations are discussed in greater detail under the heading of "Base Metals" in the section on Economic Geology since many of the base-metal occurrences are associated with them. A detailed discussion of the magnetite-chert oxide iron formations can be found under the heading of "Iron" in the section on the Economic Geology, since the Goulais River Iron Range is of this type.

Clastic Metasediments

Clastic metasediments occur as extensive units in two areas:

i) Northeast of Morrison Lake;

ii) The west central part of the map-area.

Numerous, thinly bedded interflow clastic and chemical-clastic metasediments are also common in the Goulais River Iron Range and in the felsic to intermediate and intermediate to mafic metavolcanic flows and pyroclastic rocks.

Chemical analyses (Table 4) of three samples indicate a variety of compositions exist and partly reflect the immaturity of the clastic metasedimentary accumulations. The metasediments in the Morrison Lake area and those that occur as metavolcanic interflow deposits are volcanically derived sedimentary rocks.

TABLE 4 | CHEMICAL ANALYSES OF THE METASEDIMENTS AND QUARTZ DIABASE OF THE COWIE LAKE AREA. CHEMICAL ANALYSES BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Major Components in Weight Percent

Sample Number	29	30	31	32
SiO_2	74.40	58.6	64.00	49.60
Al_2O_3	13.70	14.5	14.70	13.30
Fe_2O_3	1.18	8.99	3.76	16.30
MgO	0.18	3.53	1.11	4.82
CaO	0.35	6.18	4.90	9.11
Na_2O	5.29	3.41	5.92	2.61
K_2O	3.66	1.57	1.28	0.58
TiO_2	0.08	1.15	0.67	1.64
P_2O_5	0.01	0.32	0.14	0.14
MnO	0.02	0.16	0.08	0.24
L.O.I.	0.60	1.50	2.40	1.30
Total	99.5	99.9	99.6	99.6

Molecular Norms

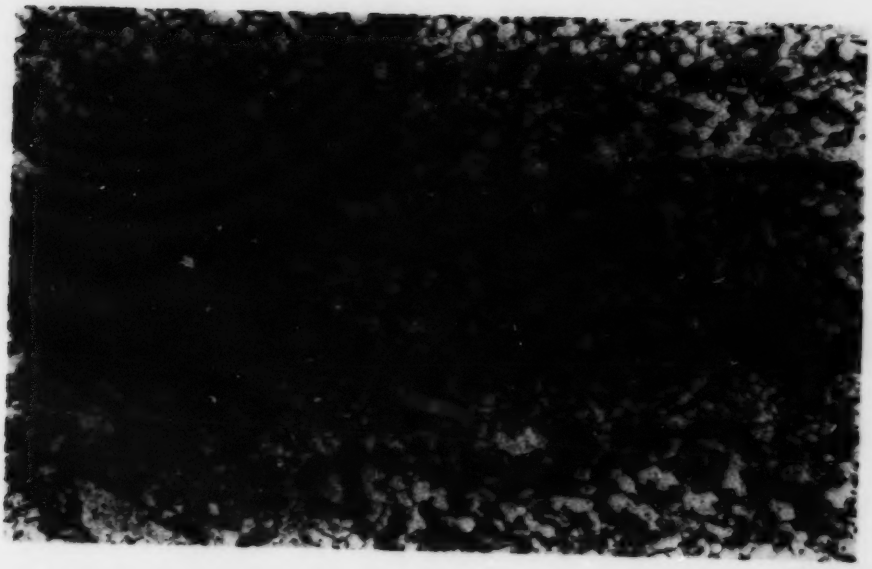
Apatite	0.311
Pyrrhot te	0.0
Ilmenite	2.422
Orthoclase	3.637
Albite	24.842
Anorthite	24.243
Corundum	0.0
Magnetite	3.480
Hematite	0.0
Enstatite	9.720
Ferrosilite	10.408
Quartz	2.770
Diopside	8.773
Forsterite	0.0
Fayalite	0.0
Hedenbergite	9.394
Normative Plagioclase Composition	49.39
Normative Colour Index	44.20

Notes:

29. G-5-66 — Pink sandstone.
30. G-5-65 — Sandstone.
31. G-5-56 — Fine-grained greywacke.
32. G-6-76 — Tholeiitic quartz diabase.

Abbreviation:

L.O.I. — Loss on ignition



OGS 16078

Photo 8–Photomicrograph of arkosic metasediment in the Morrison Lake area. Note the granoblastic texture. Plane light. Field of view is 6 mm.

The metasediments, for the most part, are not easily distinguished in the field unless sedimentary textures are preserved. This was a problem in the southwest part of the map-area where the schistose felsic metavolcanics are similar in colour and mineralogy. Many of the felsic metavolcanic schistose units may in fact be reworked tuffs.

The most common type of metasediment encountered in the field was a quartz, plagioclase, biotite schist, with secondary, epidote, chlorite, and/or hornblende. Gneissic metasediments were encountered in the Morrison Lake area near the felsic intrusive rocks. The rocks are fine to medium grained and granoblastic in texture (Photo 8). Poikiloblastic biotite and hornblende are common in the area northeast of Morrison Lake and in the west-central part of the map-area. The rocks vary from light grey-brown to dark grey on the weathered surface and light cream to dark grey on the fresh surface. The schistosity is defined by the platy minerals.

Sandstone, arkose, greywacke, siltstone, and chert are the most commonly identifiable metasedimentary rocks in the map-area, and are the dominant units in the west central and Morrison Lake areas. In the Morrison Lake area, sandstone, arkose, greywacke, and arkosic greywacke are the most common metasediments. Sandstone is usually light cream to light grey; arkose, pink to buff pink; and greywacke, light grey to dark grey. The term sandstone was used when sand-sized clastic sediments were not subdivided in the field. The units vary in thickness from 10 cm to 5 m and are schistose in texture. These units probably

represent the weathering products of the nearby metavolcanics to the north. Silica composition ranges from 58.6 percent to at least 74.4 percent, indicates the chemical variability of the units and reflects a variety of source material.

Banded sandstone, siltstone, and cherty siltstone are common in the west central part of the map-area (northwest of Loggas Lake) and graded bedding was observed in the units which are thinly bedded with beds ranging from 0.5 to 10 cm in thickness.

In thin section, clastic metasediments are sub-granoblastic to granoblastic in texture. In the less altered rocks, the constituents are subrounded to angular quartz and plagioclase with a platy mineral matrix composed of biotite, chlorite, muscovite, and hornblende. The presence of carbonate was noted in a few of the thin sections examined.

Siltstone and chert are common in the west-central part of the map-area and form interbeds containing sulphide laminae within some of the sulphide facies iron formations and in the interflow metasediments within the metavolcanic sequence. These rocks are usually dark grey brown on the weathered surface and dark grey on the fresh surface. Fine-grained quartz is the principal constituent, with minor amounts of plagioclase and epidote minerals. The cherty units vary from white to almost black on both the fresh and weathered surfaces. They are usually very fine grained. However, recrystallization has affected some units so that they appear as gritty, friable quartzite.

Argillite and slate occur as thinly bedded units with mafic to intermediate metavolcanic flows, and are usually less than 1 m thick. The colour is always black and schistosity is poorly to moderately well developed. Thin section examination reveals that this unit is composed of finely laminated carbonaceous material with very minor amounts of chert and plagioclase. The laminae are about 1.0 mm thick.

Conglomerate, gritty sandstone, and conglomeratic sandstone were observed in the lower part of the metasedimentary sequence in the west central part of the map-area and in a lens like unit west of Hanes Lake. Conglomerate is a polymictic paraconglomerate with subrounded to angular cobbles of mafic, intermediate, and felsic metavolcanics (Photo 9). The clasts occupy approximately 40 percent of the rock and vary from 1 cm to 25 cm across. The matrix is chloritic, containing metavolcanic grit. In a lens west of Hanes Lake, granitic pebbles and cobbles were noted in one outcrop. The conglomerate in the west-central part of the map-area overlies the top of the thick mafic sequence of flows representing the second stratigraphic sequence of the map-area. It probably represents a proximal facies of weathered detritus from a nearby source of volcanic rocks. The overlying laminated sandstone, siltstone, and chert may represent in this location, a period of relative quiescence in volcanic activity.

Felsic Intrusive Rocks

The felsic intrusive rocks occur in plutonic complexes associated with extensive migmatization and assimilation of the bordering metavolcanics. Migmatization and assimilation of the metavolcanics has occurred extensively in the area

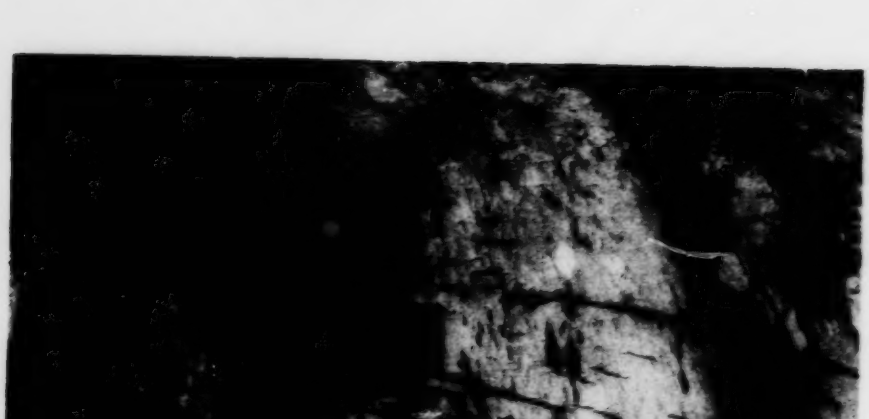


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Photo 9–Stretched, polymictic conglomerate composed of felsic, intermediate, and mafic metavolcanic clasts west of Hanes Lake on the Ragged Lake Road, 1.2 km south of the north boundary of the map-area.

south of Chubb Lake northeastward to Eileen Lake. Agmatite is particularly common (Photo 10) in the area south of Chubb Lake in which amphibolitized foliated mafic metavolcanics are intruded by a medium-grained diorite to quartz diorite (tonalite). Northeastward, xenoliths of amphibolite and paragneiss are observed with decreasing frequency. The migmatitic granitic rocks are primarily tonalitic in composition reflecting the assimilation of the metavolcanics and occur as isolated stocks in the northeast part of the map-area, west of Point Lake, and on the east and west shores of Chubb Lake. The intrusive component varies from a light-coloured quartzo-feldspathic *lit-par-lit* and pod-like injections to extensive areas of quartz diorite.

Thin section examination of the agmatite intrusive phase shows that it is composed of plagioclase, hornblende, and epidote with minor amounts of sericite in the matrix and in the metavolcanic fragments. The plagioclase is subhedral, often showing zoning and Carlsbad-Albite twinning. The composition of the plagioclase varies from An_{20} to An_{40}. The hornblende in the metavolcanic fragments occurs as arranged in parallel oriented crystals, defining the foliation, and in the matrix occurs as larger aggregates with interstitial epidote. The amphibole pleochroism is blue-green-yellow and is higher in alkali content than the hornblende of the recrystallized mafic metavolcanics elsewhere in the map-area.

The main mass of granitic rocks in the east part of the map-area consists of equigranular quartz monzonite, granodiorite, and trondhjemite, with porphyritic varieties of each. Modal analyses of some selected samples are shown in Table 5. These rocks could not be separated into separate intrusions partly due to the

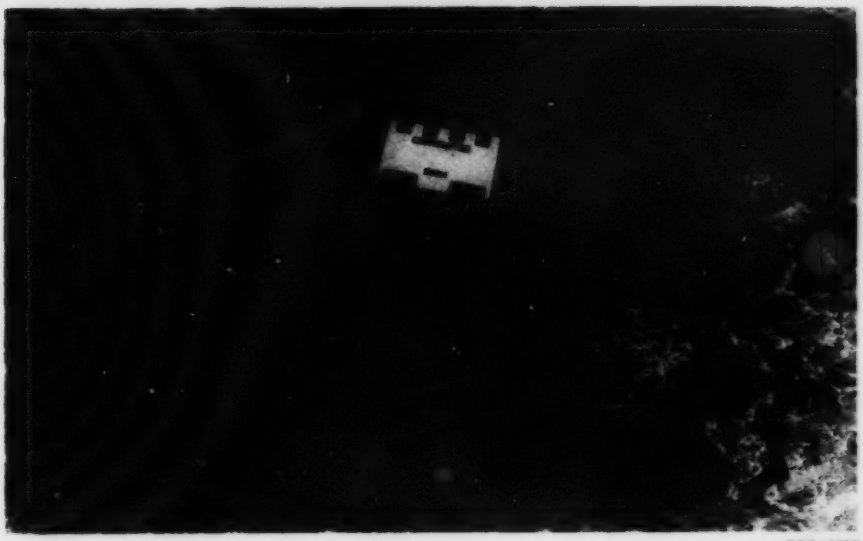

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Photo 10–Agmatite (intrusive breccia) composed of mafic metavolcanic fragments in a dioritic matrix. 1.5 km west of the Ragged Lake Camp cut off on the Ragged Lake Road.

scale of mapping and partly because discrete pluton boundaries were not observed in the field. Foliation is present in some of the outcrops which are granodioritic to trondhjemitic in composition. These rocks may be earlier intrusive phases that were later intruded by the quartz monzonite which also makes up part of the plutonic complex. The granodiorite and trondhjemite are composed of quartz, plagioclase, hornblende, chlorite, and potassium feldspar. The rocks have been classified according to L.D. Ayres (1972). These rocks are pink to grey on fresh and weathered surfaces and have an equigranular texture. The plagioclase composition is An_{35} and occurs as subhedral to anhedral crystals with varying amounts of alteration. Quartz forms larger anhedral crystals that occur interstitially. Quartz and plagioclase form large phenocrysts (3 mm) in some of the outcrops examined. Microcline and perthite are late stage, interstitial, and are anhedral in shape. Subhedral hornblende with chlorite mantles are common, and are up to 5.0 mm across.

Quartz monzonite is the most abundant granitic rock in the area. It is white to pink to light grey on the fresh and weathered surfaces and has a very low mafic mineral content ($<$10 percent). The rock is medium to coarse grained and is generally equigranular. Thin section study reveals that the quartz monzonite is composed of quartz, plagioclase, microcline, perthite orthoclase, and accessory hornblende, biotite, and epidote. Quartz and plagioclase are anhedral and the plagioclase displays altered, calcium rich, cores. From field observations, the au-

TABLE 5 MODAL ANALYSES OF SELECTED ROCKS IN THE COWIE LAKE AREA.

SAMPLE NUMBER	ROCK NAME	QUARTZ	PLAGIOCLASE	PYROXENE	HORNBLENDE	BIOTITE	POTASSIC FELDSPAR	CHLORITE	MUSCOVITE	SERICITE	SAUSSURITE	CARBONATE	OPAQUE	EPIDOTE	APATITE
A-3-52	Lapilli-tuff (Rhyolitic)	19.6	38.7	—	2.2	20.1	—	0.2	—	0.3	5.3	—	—	13.6	—
G-15-170	Tuff (Rhyolitic)	4.7	53.4	—	—	—	—	1.3	36.7	—	0.6	2.9	0.4	—	—
G-51-383	Calc-alkaline Dacite	35.1	48.9	—	—	7.5	7.2	—	—	—	—	—	—	1.2	—
A-52-294	Felsic schist (Rhyolitic)	36.1	19.7	—	—	—	—	10.5	—	15.3	7.7	—	—	10.6	0.1
G-49-376	Tholeiitic Basalt (Schistose)	—	14.0	71.5	—	—	—	—	—	0.9	4.9	—	8.7	—	—
G-6-69	Mafic-Intermediate Metavolcanic Schist	11.9	53.9	—	31.5	10.3	—	—	—	—	1.4	—	0.7	0.3	—
G-48-365	Quartz Diabase	—	31.8	13.4	32.5	—	—	—	—	2.2	12.4	—	7.7	—	—
G-35-301	Metasediment (Quartzite)	60.0[2]	—	—	—	—	—	1.1	48.9	—	—	—	—	—	—
A-46-273	Trondhjemite	38.7	41.8[1]	—	2.9	3.2	10.4	2.2	—	—	—	—	0.2	0.6	—
G-11-137	Granodiorite	14.0	57.0	—	15.3	1.3	12.0	1.4	—	8.7	—	0.2	tr	0.1	—
G-40-335	Trondhjemite	37.5	32.6	—	—	—	5.0	6.4	—	13.6	0.8	—	—	3.9	—
A-43-264	Hornblende Trondhjemite	12.1	19.1	—	32.7	5.7	—	1.8	—	19.5	1.7	—	1.8	4.8	0.8
G-41-339	Quartz Monzonite Granodiorite	25.5	31.8	—	3.2	6.1	7.7	1.3	—	16.8	2.8	—	0.5	4.1	0.2
G-6-78	Quartz Monzonite	39.7	21.2	—	1.3	4.5	13.7	0.3	—	14.9	1.2	—	0.6	2.6	—

Footnotes
[1]includes alteration to sericite
[2]Quartz with minor albite - fine-grained groundmass

Abbreviation
tr — trace amounts

thor has interpreted that the quartz monzonite probably composes the bulk of three of the plutons.

In the southwest corner of the map-area, a large pluton (of which only a small part was mapped) intrudes felsic and intermediate metavolcanic schists. The composition varies from granodiorite to quartz monzonite. The foliations of the surrounding metavolcanics are cut by the intrusion.

A large pluton of quartz monzonite composition intrudes the metavolcanics in the Morrison Lake area. The foliations of the metavolcanics parallels the margin of the intrusion. The quartz monzonite is cut by aplite dikes and veins of the same composition, and in places the rock is syenitic. Metasomatism of the metasediments and metavolcanics is extensive southeast of Annibal Lake. Metavolcanic and metasedimentary xenoliths are common in this region. The foliations of the surrounding metavolcanics and metasediments are generally concordant to the boundary of the pluton.

At the north end of Point Lake a large pluton, which intrudes the felsic and mafic metavolcanics, is composed of quartz monzonite, granodiorite, and nepheline syenite. The relationship between one type of granitic rock and another was not observed. The foliation of the surrounding metavolcanics is concordant to the intrusive margin. The nepheline syenite was observed northeast of Point Lake although the size of the nepheline-bearing zone was not determined. In thin section, the nepheline syenite is composed of equigranular plagioclase, orthoclase, epidote, sericite, saussurite, chlorite, carbonate, opaque minerals, and nepheline. The nepheline comprises less than 1 percent of the rock.

No distinct boundaries were observed between the different phases of granitic rocks in the east part of the map-area. Aplite dikes and veins are common in all of the granitic rocks, and are generally medium- to coarse-grained leucocratic and quartz monzonite in composition. The attitude of these veins are usually parallel to the major joint sets in the granitic rocks.

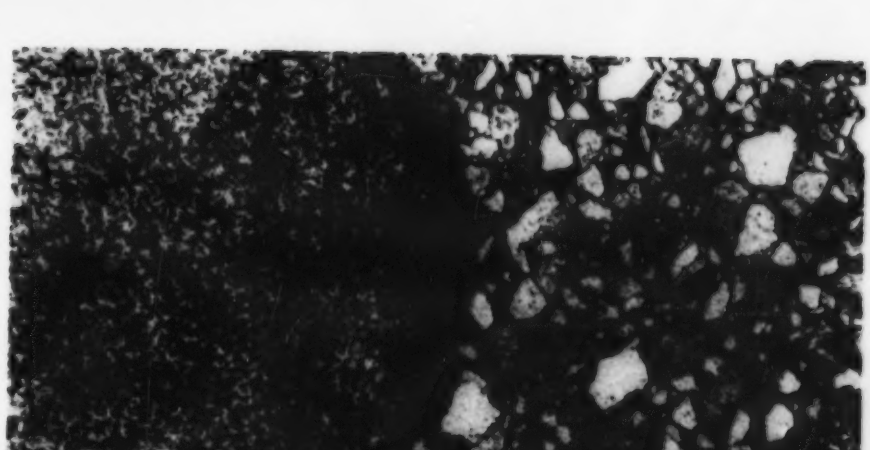
MIDDLE PRECAMBRIAN

Huronian Supergroup

COBALT GROUP

Gowganda Formation

An outlier of Huronian sedimentary rocks was located in the southwest portion of the map-area; which is the northernmost documented occurrence of Huronian rocks in the Algoma region (Grunsky and Arengi 1978a), although such rocks are abundant in the Cobalt and Kirkland Lake areas of the Timiskaming region (Ayres *et al.* 1971b). The outlier covers approximately 0.8 km^2 with 5 to 10 percent outcrop exposure. The outlier has a stratigraphic thickness of 53 m and



OGS 16081

Photo 11–Photomicrograph of Gowganda Formation paraconglomerate in the southwest part of map-area, note angular quartz and feldspar arkosic matrix. Plane light. Field of view is 6 mm.

unconformably overlies the Early Precambrian (Archean) rocks that are predominantly felsic metavolcanics.

E.C. Grunsky and J.T. Arengi (1978b) stated the following:

The outlier is bounded to the north by a major east-west fault. Sheared outcrops in the northern part of the outlier indicate that it was faulted into place. Elsewhere the contact with the underlying Precambrian rocks is not exposed; however, field evidence indicates an angular unconformity. The Early Precambrian rocks which are metamorphosed and foliated include mafic flows, felsic pyroclastic rocks and achists, sandstone, and siltstone. The foliation of these underlying rocks trends approximately N50°W and dips vertically or steeply to the north. The outlier is intruded by two quartz diabase dikes trending at approximately N50°W which are part of a Late Precambrian dike swarm that has been dated at 1035 Ga (Wanless 1970).

The beds of the lower part of the outlier strike N65°W and dip 28°N. They consist of polymictic to oligomictic paraconglomerate containing angular to well rounded clasts of metasedimentary, metavolcanic, and granitic rocks. Orthoconglomerate interbeds composed mainly of pink, granitic clasts are also present. The metavolcanic and metasedimentary clasts were probably derived locally. Clast sizes in the orthoconglomerate range from coarse sand to boulders 0.5 m in diameter; however, most clasts are between 0.5-5.0 cm. Moderately to well rounded granitic clasts are generally the largest clasts and comprise more than 60% of the clasts that are present in the orthoconglomerate. The matrix of both the orthoconglomerate and paraconglomerate ranges in composition from gritty, pinkish arkose to dark grey greywacke [Photo 11]. The gritty, arkosic matrix is predominant in the orthoconglomerate. The stratigraphically lowest orthoconglomerate bed is probably near the unconformity since it contains more metavolcanic and metasedimentary clasts than conglomerates higher in the sequence.

The upper part of the Huronian sequence consists of paraconglomerate with interbeds of pink arkose, dark grey greywacke, siltstone, and orthoconglomerate. The orthoconglomerate interbeds are

up to 1.0 m thick, and are composed exclusively of well-rounded, pink, granitic pebbles. The arkose and greywacke are commonly granular and pebbly, and contain small, pink, granitic clasts. The siltstone occurs as dark grey fine-grained interbeds less than 1.0 m thick.

About 80% of the clasts in the paraconglomerate are well rounded, grey, or pink, massive to foliated, quartz monzonite to granodiorite, ranging in size from 1.0 cm to 15.0 cm. The metavolcanic and metasedimentary clasts are generally smaller, ranging from 0.5 to 2.0 cm in diameter, and are angular to subrounded. Thin sections of the paraconglomerate show that the matrix contains angular to rounded grains of quartz (50%), plagioclase (25%), and potassium feldspars (10%), together with muscovite (10%), biotite (5%), and minor, minute grains of hematite and pyrite. Grain sizes range from 0.16 mm-1.5 mm. Some feldspars are fresh and some are highly altered. Quartz grains exhibit undulatory extinction. A matrix of this composition and texture indicates derivation from a granitic terrain.

Discussion

The sedimentary rocks of the outlier are similar to those of the Gowganda Formation of the Huronian Supergroup (Collins 1925; Robertson 1968; Card *et al.* 1972; Roscoe 1969, 1973; Wood 1973) and are especially typical of the basal unit of the Gowganda Formation where it unconformably overlies Early Precambrian terrain (Chandler 1973; Wood 1975). According to Roscoe (1969, 1973) the presence of hematite which causes the pink colour in the gritty arkose implies an oxidizing environment of deposition, and places the rocks of this outlier in the Cobalt Group. However, the pink of both the arkose and the matrix of the conglomerates may also in part be attributed to the pink feldspars.

The discovery of this outlier proves that the Huronian sedimentary cover was more extensive than previously known. Air photo interpretation in the vicinity of lineaments, faults, and topograpic highs may help in locating other outliers to the south and east.

LATE PRECAMBRIAN

Mafic Intrusive Rocks

Porphyritic and Non-porphyritic Quartz Diabase

Mafic intrusive dikes that are parallel to the regional foliation, predominant joint sets, and lineaments are very common in the map-area. These dikes can be traced along strike for several kilometres and are usually less than 50 m in width. These dikes have been observed to bifurcate and cross cut each other. Northwest of Red Pine Lake, a large sheet of quartz diabase has intruded the mafic to intermediate metavolcanics from which several dikes extend into the metavolcanics. This intrusion may be either a sill or pluton from which some of the dikes originate.

The quartz diabase is generally medium grained, light to dark grey on the weathered surface and dark grey to black on the fresh surface. The weathered rind is usually less than 3.0 mm in thickness. The diabasic to ophitic textures can be observed in the field.

In thin section, these rocks are revealed to be fresh, highly altered, and are composed of plagioclase, hornblende, augite, actinolite, uralite, epidote, chlorite, saussurite, sericite, and late stage interstitial quartz. The plagioclase occurs as

zoned and twinned euhedral laths up to 1.0 mm long and is often highly altered to sericite and saussurite. Hornblende usually mantles the subhedral to anhedral augite. Chlorite, in turn often mantles the hornblende. Opaque minerals consisting of pyrite, pyrrhotite, and magnetite are euhedral to anhedral in shape and compose up to 10 percent of the rock. A modal analysis is shown in Table 5.

The porphyritic variety of the quartz diabase is part of the same non-porphyritic variety. In outcrop it was observed that the non-porphyritic variety grades into the porphyritic type within a single dike. The phenocrysts are composed of plagioclase crystals up to 2.0 cm across displaying subhedral to euhedral shapes. These crystals display zoning and are greenish in places. They were observed to compose as much as 40 percent of the rock, but usually compose from 5 to 10 percent.

Olivine Diabase

Olivine diabase is not common in the map-area and was observed in three localities east of Cowie Lake; in the south-central part; and in the west part of the map-area. The trend of these dikes follow the regional foliation and were observed cross cutting the quartz diabase east of Cowie Lake.

Colour varies from dark grey-brown on the weathered surface to black on the fresh surface with the weathered rind being as thick as 1.0 cm. The texture is ophitic to diabasic and is generally coarser grained than the quartz diabase.

Phanerozoic

CENOZOIC

Quaternary

PLEISTOCENE AND RECENT

Pleistocene glaciation has given rise to erosional and depositional features within the map-area. Glacial striae were observed throughout the map-area indicating a general trend of S25°W obtained from 24 measurements. Polished surfaces and plucking were also observed. Most of the area is covered by glacial overburden, but it is thicker in the areas west of Cowie Lake and in the southern and northern parts of the map-area. Drift-filled valleys are common in the granitic terrain. The Goulais River area and the adjacent mafic metavolcanic terrain to the northwest are blanketed by fluvial gravel, fine sand, and fine silt that may have been part of an area of glacial outwash.

The glacial overburden is composed of large boulders, cobbles, and sand composed of various rock types and appears to be most common on the sides of

many of the hills in the area and on the tops of some of the lower hills. Many hilltops are bare of glacial deposits.

The Goulais River area is primarily a sand plain composed of fine sand and silt that is partly fluvial in origin, with much of the sediment being derived from the unconsolidated glacial material of the surrounding area.

Recent deposits in the map-area consist of organic accumulations overlying the Pleistocene deposits; the fluvial sand and silt of the Goulais River; and organic debris that is presently accumulating in the swamps of the low lying areas in the northwest part of the map-area.

REGIONAL METAMORPHISM

Three distinct facies of metamorphic mineral assemblages have been observed in the map-area. These are low to high grade greenschist and low grade hornblende-hornfels facies (Winkler 1976). The mafic metavolcanics have been used solely to determine the metamorphic facies within the map-area, although the felsic metavolcanics indicate mineralogic and textural changes have occurred as well.

Low-grade greenschist facies assemblages observed in the mafic metavolcanics consist of clinozoisite-albite-actinolite-chlorite and are common in the central and northwest parts of the map-area. This facies of metamorphism can be further subdivided using the mineralogic assemblages observed in thin section. Table 6 outlines the metamorphic assemblages as observed for the mafic and felsic metavolcanics. The lowest grade of greenschist facies metamorphism occurs in the northwest and north-central parts of the map-area in which the mafic metavolcanic flows are composed of altered plagioclase, saussurite (clinozoisite), sericite, chlorite, $\pm$carbonate, and a submicroscopic groundmass. Further to the east and southeast, the metavolcanic flows show the development of uralite/actinolite in addition to the mineralogy already mentioned which defines low grade greenschist metamorphism according to H.G.F. Winkler (1976). It was observed in thin section that the clinozoisite begins to recrystallize to epidote in this assemblage and the groundmass is composed of microscopic crystals.

Foliation is generally poorly developed in the northwest part of the map-area. To the east and southwest, with increasing metamorphic grade, however, the foliation develops into a marked schistosity. The felsic metavolcanics are difficult to use as indicators of metamorphic grade. However, the degree of recrystallization aids in interpretation. Subgranoblastic textures are indicative of low grade greenschist facies, while varying degrees of granoblastic texture indicate varying degrees of medium- to high-grade greenschist facies.

Contact metamorphism in the area is accompanied by the development of two types of mineral assemblages:

i) Albite-epidote-hornfels facies;
ii) Hornblende-hornfels facies.

Contact metamorphism occurs along the boundaries of the granitic complexes in the map-area, and the effects are observed in aureoles of contact meta-

TABLE 6 | METAMORPHIC MINERAL ASSEMBLAGES IN THE METAVOLCANICS OF THE COWIE LAKE AREA.

REGIONAL METAMORPHISM	
Low Grade Greenschist Facies	
1) Clinozoisite + Albite + Chlorite + Carbonate	[Mafic to Intermediate Metavolcanics]
2) Clinozoisite + Albite + Uralite/Actinolite ± Chlorite ± Carbonate Quartz + Albite + Muscovite + Epidote + Chlorite	[Felsic to Intermediate Metavolcanics]
CONTACT METAMORPHISM	
1) Albite-Epidote Hornfels Facies	
Hornblende + Plagioclase + Epidote	Mafic to Intermediate Metavolcanics
Plagioclase + Quartz + Epidote + Hornblende	Felsic to Intermediate Metavolcanics
2) Hornblende-Hornfels Facies	
Hornblende + Plagioclase	Mafic to Intermediate Metavolcanics
Plagioclase + Quartz + Hornblende + Epidote	Felsic to Intermediate Metavolcanics

morphic assemblages that extend up to 0.5 km into the metavolcanics. The metamorphic assemblages observed (Table 6) indicate upper grade albite-epidote-hornfels facies to lower grade hornblende-hornfels facies (Winkler 1976, p.248) metamorphic rank. Hornblende hornfels facies is observed along the contact of the metavolcanics with the granitic intrusions and within the mafic metavolcanic xenoliths in the granitic rocks. The albite-epidote-hornfels facies penetrates into the metavolcanic margin. Accompanying these distinctive mineralogies is an increase of grain size, increasing schistosity, and the development of gneissic textures. The mafic metavolcanics display granoblastic textures and contain amphiboles. The felsic metavolcanics develop granoblastic textures of quartz and plagioclase with accompanying poikiloblastic and porphyroblastic hornblende. The area east of Cowie Lake and north of the Goulais River displays these features.

STRUCTURAL GEOLOGY

The Cowie Lake area consists of an overturned, steeply dipping stratigraphic succession consisting of metavolcanics and metasediments. Foliation is observed in submassive schist, schist, and gneiss. Figure 4 shows a contoured Schmidt net (Turner and Weiss 1963) of 806 foliation attitudes determined from rocks in the map-area. The plot shows a concentration of poles to the foliation at about S30°W with a plunge varying from 0 to 20 degrees. This represents the predomi-

Figure 4–Equal Area Plot of foliations, Cowie Lake Area. Contours at 0.5%, 5.5%, 10.5%, 20.5%, 40.5%, and 60.5%. 806 measurements.

nant foliation of the map-area which is N60°E with a dip ranging from 60°N to 85°S. A wide spread of steeply dipping foliations is observed around the perimeter of the net which indicates changes in the foliation due to local shearing and the tendency of the foliations to follow the margins of the granitic intrusions. Figure 5 shows a contoured equal area projection of 50 lineations taken in the map-area. A maximum exists trending N20°E plunging from 65° to 90° and another maximum occurs at E25°S plunging from 20° to 90°. The first maximum of N20°E is about 90° from the maximum of the foliation poles of Figure 4. This indicates that the lineations are parallel to the dip of the foliation planes. The second maxima occurs from measurements near the Chubb Lake area and is related to the granitic intrusions.

Figure 6 shows a contoured equal area net of the bedding planes combined with top determinations from metasediments, metavolcanic flow contacts, and pillowed flow planes. The maximum of this plot coincides with that of Figure 4. Thus, it can be assumed in general that the regional foliation is parallel to the bedding planes in the map-area. Twenty eight top determinations included in Figure 6 indicate an overturned northeasterly dipping, southwest-facing se-

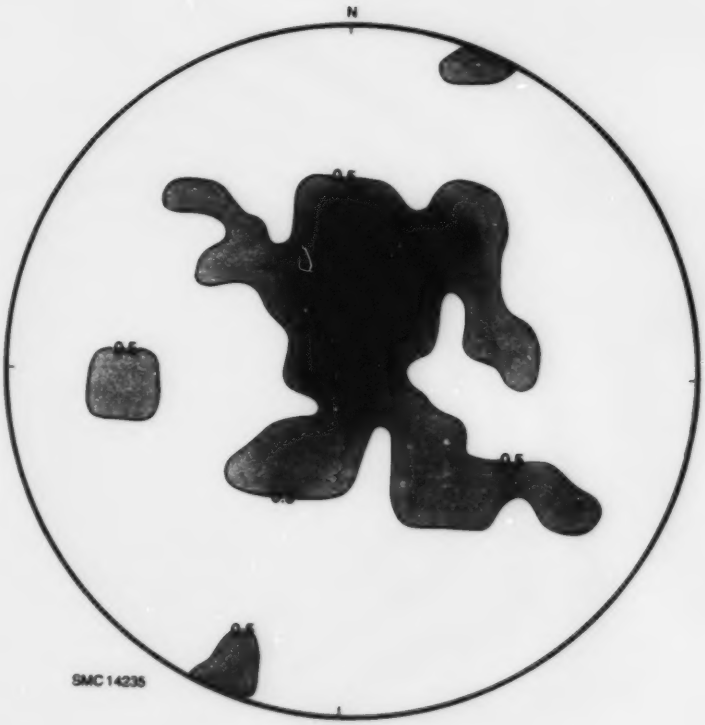


Figure 5–Equal Area Plot of lineations, Cowie Lake Area. Contours at 0.5%, 2.5%, 5.5%, and 7.5%. 50 measurements.

quence that is probably an overturned monocline. It should be noted that the dip of the foliations are steeper in the north part of the map-area, tending towards the vertical whereas in the southern part of the map-area, dips vary from 40° to 70°NE. This indicates an increasing degree of overturning to the southwest. Foliations near the granitic margins also tend to be vertically dipping.

Top determinations are inconsistent in the metasediments in the west part of the map-area. The author believes that the inconsistancies are the result of diagenetic slumping.

Joint measurements were taken in the granitic terrain in the east part of the map-area. Figure 7 displays a contoured equal area net from 110 measurements made in the field. It can be seen in this plot that two maxima occur which correspond to the prominant joint set within the map-area. The two prominent joint directions are vertically dipping and strike at about N45°E and N45°W. The aplite dikes and veins that are common throughout the terrain are parallel to these directions.

The numerous diabase dikes that occur throughout the map-area strike at about N45°W to N50°W parallel to the regional foliation, although a few dikes

Figure 6–Equal Area Plot of bedding planes, Cowie Lake Area. Contours at 0.5%, 2.5%, 5.5%, and 10.5%. 106 measurements.

were noted to strike parallel to the joint set of N45°E.

Early investigations of the map-area by the author suggested that the area may be part of a large regional plunging fold. Evidence to support this belief could not be found during the field season and the field evidence collected by the author supports an overturned monoclinal succession.

Faults and Lineaments

Several faults exist in the Cowie Lake area, the largest one, the Goulais River Fault, extends across the area from Witchdoctor Lake in the northeast and passes through the western boundary of the map-area in the southwest. This fault can be traced on airphotographs and evidence of shearing exists in many places along the zone. Fault gouge can be found a few metres west of the bridge over Witchdoctor Lake in the granitic rocks, and along the shore of the Goulais River in the central part of the area. Intense shearing is often displayed

Figure 7–Equal Area Plot of joint sets, Cowie Lake Area. Contours at 0.5%, 2.5%, 5.5%, and 7.5%. 110 measurements.

in the metavolcanics. This fault can be traced on the aeromagnetic map (ODM-GSC 1963) and is a major structural feature on the regional geological compilation map (Ayres *et al.* 1971). The Goulais River Fault moved sometime before the intruding diabase dikes which are dated at 1035 m.y. (Wanless 1970) and probably after the deposition of Huronian rocks. A fault that is parallel to the Goulais River Fault occurs to the south of it in the southwest part of the map-area and marks the northern limit of the Huronian sedimentary rocks. These two faults are most probably of the same age. Diabase dikes parallel the Goulais River Fault in a few places and intrude the fault in an area about 2.0 km southwest of Forester Lake. Offset on the Goulais River Fault appears to be left handed. However, insufficient information is available to determine the nature of the fault which may be a dip-slip vertical type.

A south-southwest trending fault occurs through the south end of Chubb Lake which appears to be a vertical strike-slip fault with minor left-hand movement. This fault may be part of a structurally weak zone at the granitic margin of the metavolcanic belt.

Another large fault occurs, it trends west-southwest from Hanes Lake through to Red Pine Lake in which intense vertical shearing was observed in the

mafic metavolcanics of the area. The amount of movement, if any, is not known. Another fault parallel to the east shore of Hanes Lake displays intense shearing of the felsic pyroclastic rocks along the east shore.

The major lineaments in the map-area are generally parallel to the regional foliation and major joint set. These are easily seen on airphotographs. Many of the lineaments join the prominent faults or cross cut them. This suggests that some of these lineaments are related to faulting.

CORRELATION OF GEOLOGY AND GEOPHYSICS

Aeromagnetic map 2215G, ODM-GSC (1963) covers the Cowie Lake map-area. Due to the presence of the Goulais River Iron Range and the Goulais River Fault, lithologic distinction from the aeromagnetic expressions cannot be made for most of the map-area. In the southwest part of the map-area, however, the mafic metavolcanic units are anomalously distinct from the felsic metavolcanics and the outlines of the two granitic intrusions can be observed. East of Point Lake, the felsic metavolcanic units can be distinguished from the enveloping granitic terrain. The only visible fault that can be observed from the aeromagnetic map is the Goulais River Fault trending southwestward from Goulais Lake into the southwest part of the map-area. It reveals itself as magnetic depressions. The disruption of the Goulais River Iron Range aeromagnetic pattern in the Teepee Lake area is probably due to the Goulais River Fault and the pinching out of the iron formation. The aeromagnetic highs southeast of Hanes Lake enabled the author to locate the minor iron formations that are possibly local basins of chemical metasediments associated with the Goulais River Iron Range.

In the central part of the map-area, the aeromagnetic contours faintly indicate the transition from a predominantly mafic to intermediate metavolcanic environment to a felsic to intermediate metavolcanic environment.

Southwest of Watson Lake, an aeromagnetic high expresses the presence of the diabase intrusion in the northwest part of the map-area. Due to the aeromagnetic overprint of the Goulais River Iron Range and the Goulais River Fault and their general parallelism with the regional foliation, the diabase dikes are not readily apparent on the magnetic maps.

PETROCHEMISTRY AND STRATIGRAPHIC SYNTHESIS OF THE EARLY PRECAMBRIAN METAVOLCANIC-METASEDIMENTARY SUCCESSION

The Cowie Lake area has been interpreted by the author as an overturned, steeply dipping succession of metavolcanics and metasediments. The oldest unit occurs toward the northeast and is composed of alternating mafic to intermediate metavolcanic flows and felsic to intermediate flows and pyroclastic rocks. The lower sequence of metavolcanics extends from northwest of Hanes Lake, southeasterly to Cowie Lake, southward to Annibal Lake, and as far as the

southeast corner of the map-area. This lower sequence is structurally somewhat complex due to the granitic intrusions and the variation in strike of the foliation at the margins of these intrusions. Chemical analyses of the mafic metavolcanics in this sequence are shown in Tables 2 and 3 and volcanic petrochemical trends can be observed in Figures 2 and 3. The chemical analyses are marked by numbers on Map 2426 (back pocket). Chemical analyses of this lower sequence indicate the flows consist of tholeiitic and calc-alkaline rock types varying from tholeiitic basalt to calc-alkaline andesite, dacite, and rhyolite. The Goulais River Iron Range and its extension to the northwest up to Hanes Lake marks the top of this lowermost sequence, and represents a period of reduced volcanic activity.

The second sequence overlying the lowermost sequence can be divided into two regimes based on petrochemistry. In the northwest to north-central part of the map-area, the thick sequence of mafic to intermediate metavolcanic flows are almost exclusively tholeiitic in nature. These rocks were probably derived from the northwest. In the central part of the map-area, a facies change occurs in which the tholeiitic flows derived from the northwest are interbedded with calc-alkaline flows and pyroclastic rocks from a volcanic centre that existed in the Goulais River area. Pyroclastic breccia, thick felsic flows, and thinly bedded mafic to intermediate flows occur in this area. Many of the thinly bedded mafic to intermediate flows show sheared flow tops up to 20 cm in thickness which may represent subaerial flow tops and suggest that the calc-alkaline volcanic centre may have been subaerially exposed at times. Pillowed metavolcanics are absent in this area, but are found to the south and west. The felsic metavolcanics of this area extend eastward to the Cowie Lake area where the felsic metavolcanic succession begins, overlying the Goulais River Iron Range. The felsic to intermediate calc-alkaline volcanic succession continues to the southwest part of the map-area and is composed of flows and pyroclastic rocks that grade northwestward into the mafic to intermediate metavolcanics of the Goulais River area.

Overlying the mafic to intermediate metavolcanic flows in the west part of the map-area is a clastic metasedimentary sequence that indicates an interruption of the volcanic activity to the northwest. This sequence grades into the fine-grained felsic metavolcanic schists to the southeast. Mafic to intermediate metavolcanic pillowed flows overlie these metasediments, followed by an influx of felsic tuffs, and schists overlying the mafic to intermediate flows. The southwestern part of the map-area consists of tholeiitic mafic to intermediate metavolcanics similar to flows in the northwest which are interbedded with calc-alkaline felsic pyroclastic rocks similar to volcanic rocks in the southeast.

Tables 7 and 8 show how the composition of the metavolcanics varies across and parallel to the stratigraphy.

ECONOMIC GEOLOGY

Mineral exploration in the Cowie Lake area started in the early 1900s, and shortly thereafter the Goulais River Iron Range consisting of magnetite-chert (oxide facies) iron formation was discovered (Gross 1965). Exploration for iron ore on the Goulais River Iron Range was carried out between 1910 to 1922, 1941

TABLE 7 | CLASSIFICATION OF THE MAFIC TO INTERMEDIATE METAVOLCANICS OF THE COWIE LAKE AREA ACROSS THE STRATIGRAPHY.

Chemical Analyses Number	Location	Classification (Irvine & Baragar 1971)	Classification (Jensen 1976)	
12	Hanes Lake	CAA	CAB	
11	Southwest of Hanes Lake	TB	KB	
27	Cowie Lake	TB	TB	lowermost
28	Cowie Lake	CAA	CAA	sequence
1	Northwest of Teepee Lake	AB	AB	
14	Northwest of Teepee Lake	CAD	CAA	
5	Northwest of Hanes Creek	CAB	TB	
2	Northwest of Hanes Creek	TB	TB	
9	Hanes Creek	CAD	TB	middle
8	Teepee Lake	TB	TB	sequence
10	West of Hanes Creek	CAA	CAB	
3	Southeast of Red Pine Lake	TB	TB	
7	Southwest of Red Pine Lake	TB	TB	
13	Goulais River West of Cowie Lake	CAA	CAB	
15	South of Private Lake	CAA	CAA	
6	Roar Lake	CAA	TB	

Abbreviations:
AB Alkali Basalt
KB Komatiitic Basalt
TB Tholeiitic Basalt
CAB Calc-Alkaline Basalt
CAA Calc-Alkaline Andesite
CAD Calc-Alkaline Dacite

to 1944, and 1965 to 1966. Most of this work was performed by the Algoma Steel Corporation Limited. Although many thin units of sulphide or oxide iron formations exist in the area, the Goulais River Iron Range is the only iron deposit that has economic potential.

Base-metal exploration received little attention until the 1960s at which time a few companies examined the area for base-metal prospects.

A list of assessment work reports and mineral occurrences is shown in Table 9. Much of the information obtained was obtained from the Assessment Files Research Office, Ontario Geological Survey, Toronto. These files are duplicated in the Resident Geologist's Office in Sault Ste. Marie. Additional information was obtained from the files of the Algoma Steel Corporation Limited and HBOG Mining Limited with their permission. Other sources of information are noted from selected references and files of the Geoscience Data Centre, Ontario Geological Survey, Toronto.

TABLE 8 | CLASSIFICATION OF THE MAFIC TO INTERMEDIATE METAVOLCANICS PARALLEL TO THE STRATIGRAPHY OF THE COWIE LAKE AREA.

Chemical Analysis Number	Classification (Irvine and Baragar 1971)	(Jensen 1976)
27 EAST	TB	TB
28	CAA	CAA
9	CAD	TB
14	CAD	CAA
15	CAA	CAA
1	AB	AB
8	TB	TB
10	CAA	CAB
12	CAA	CAB
5	CAB	TB
11	TB	KB
2	TB	TB
3	TB	TB
7	TB	TB
6 NORTHWEST	CAA	TB

Abbreviations:
AB Alkali Basalt
KB Komatiitic Basalt
TB Tholeiitic Basalt
CAB Calc-Alkaline Basalt
CAA Calc-Alkaline Andesite
CAD Calc-Alkaline Dacite

Base-Metals

Base-metal occurrences observed in the map-area exist exclusively as metal sulphides in the form of banded sulphide iron formations and as volcanic exhalative lenses interbedded within the metavolcanics. These units are generally associated with interflow metasediments within the mafic to intermediate metavolcanic flows and interbedded metasediments, within the felsic to intermediate metavolcanic flows and pyroclastic rocks, and at the contacts between mafic and felsic metavolcanics.

Electromagnetic conductors and magnetic anomalies occur in the area west of Cowie Lake, south of the Goulais River, and also in the area southeast and west of Hanes Lake. Both of these areas consist of alternating mafic and felsic metavolcanic flows and tuffs representing a variable volcanic environment.

Many of the banded sulphide iron formations are less than 2 m thick and cannot be traced more than a few hundred metres along the strike. The sulphide iron formations are typically interbedded with siltstone, graphite, chert, argillite,

TABLE 9 | **PROPERTIES AND OCCURRENCES IN THE COWIE LAKE AREA.**

Number (as on Map 2426, back pocket)	Company Name, Occurrence	Date	Township	Type of Work	Mineralization Detected in Field	Mineralization Detected in Assay	Data Source
1.	The Algoma Steel Corporation Ltd. (Goulais River Iron Range)	1941-1944	Nahwegezhic	GL,DD,TR		Fe	ASC[1]; CMH, 1977/78; MRC No.11[7]; SMDR[2]; MOORE (1925, 1946)
2.	The Algoma Steel Corporation Ltd. (McPhail Iron Deposit)	1922	Gaudry	GL,DD,TR		Fe	IOC[4]; MRC No.11; SMDR; MOORE (1925, 1946)
3.	Brennan Occurrence	1967	Gapp	TR (GP?)	cp,ga,sp, po,py	Cu,Pb,Zn Fe	RGR[6], FIELD[5]
4.	Hanes Lake North Occurrence	1977	Gapp		py (sulphide, IF)	Au,Ag,Cu, Pb,Ni	FIELD[5]
5.	Hanes Lake West Occurrence	?	Gapp	TR	py,po	Au,Ag,Cp, Pb,Zn,Fe	FIELD[5]
6.	HBOG Mining Limited	1976	Gapp, Lunkie	ABEM,GP, DD,TR	py,po,sp cp,gn	Fe,Cu,Ni, Pb,Zn	HBOG[3], AFRO No.2.1955
7.	Humbleford Exploration Ltd. [1968]	1968	Gaudry	GP			AFRO No. 63.2406
8.	McClintock Occurrence	1923?[4]	Gaudry		hem	Fe	IOC[4], MRC No.11
9.	Teepee Occurrence	1977	Gapp		py (sulphide IF)	Au,Ag,Cu, Pb,Fe	FIELD[5]

Abbreviations:

ABEM Airborne Geophysical Survey (EM & MAG)
DD Diamond Drilling
GL Geological
GP Geophysical (Ground work)
TR Trenching

Footnotes:

1 — Files of the Algoma Steel Corporation, Sault Ste. Marie.
2 — Source Mineral Deposit Record-Geoscience Data Centre-Ministry of Natural Resources, Toronto
3 — Files of HBOG Mining Limited, Toronto.
4 — Report of the Iron Ore Committee with Appendix, Ont. Dept. Mines, 1923, p.196.
5 — Field observations made by the author and/or assistants during field season of

Table 9 continued

Au	Gold
cp	Chalcopyrite
Cu	Copper
gf	Graphite
gn	Galena
hem	Hematite
mag	Magnetite
Ni	Nickel
Pb	Lead
po	Pyrrhotite
IF	Iron Formation

1977.
6 — Resident Geologists' Report, 1967, MP17, p.7-9.
7 — Shklanka, R. - Iron Deposits of Ontario, MRC No.11.

Note: Assays by Geoscience Laboratories, Ontario Geological Survey.

TABLE 10 | QUANTITATIVE ASSAY RESULTS FOR SAMPLES FROM COWIE LAKE AREA. ASSAYS BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

	Ag oz/ton	Au oz/ton	Percent Cr	Percent Cu	Percent Pb	Percent Zn	Percent Ni	Percent Fe	Percent U_3O_8
1. G-2-27	tr	0.03	<0.01	0.01	<0.01	<0.01	<0.01	–	–
2. G-2-30	tr	0.01	–	–	–	–	–	–	–
3. G-2-37	tr	0.02	0.01	0.02	0.01	<0.01	<0.01	–	–
4. G-3-44	–	tr	–	–	–	–	–	30.6	–
5. G-7-96	–	tr	–	–	–	–	–	15.0	–
6. G-7-97	0.23	0.01	0.006	0.12	0.01	0.082	0.02	42.0	–
7. G-7-100	–	tr	–	–	–	–	–	28.5	–
8. G-7-101	–	tr	–	–	–	–	–	7.72	–
9. G-7-111	–	tr	–	–	–	–	–	7.25	–
10. G-12-152	tr	tr	0.01	0.01	<0.01	0.01	0.01	19.6	–
11. G-18-190	–	tr	–	–	–	–	–	30.3	–
12. G-27-234	tr	0.02	–	0.02	<0.01	0.01	–	20.6	–
13. G-44-351	–	–	–	–	–	–	–	37.9	–
14. A-3-46	tr	tr	–	0.02	<0.01	<0.01	–	9.00	–
15. A-4-65	–	–	–	–	–	–	–	15.3	–
16. A-6-90	tr	tr	–	0.03	0.01	0.01	–	22.2	0.008
17. A 7-94	tr	tr	–	0.02	<0.01	0.01	–	9.57	–
18. A-20-165	–	tr	–	–	–	–	–	23.7	–
19. A 21-169	–	tr	–	–	–	–	–	32.5	–
20. A-47-283	–	–	–	–	–	–	–	6.91	–
21. A-48-287	–	–	–	–	–	–	–	34.5	–
22. A-55-304	–	–	–	0.034	84.0	1.4	–	–	–

Location of Samples:

1. G-2-27 **Banded sulphide iron formation** - 0.5 km northwest of Hanes Lake - Occurrence No.4.
2. G-2-30 **Banded sulphides with interflow sediments** - 0.2 km west of Hanes Lake - Occurrence No.5.
3. G-2-37 **Sulphides in quartzite/chert iron formation** - 1.6 km north Teepee Lake - Occurrence No.9.
4. G-3-44 **Brecciated magnetite/sulphide iron formation** - 2 km north of Teepee Lake - Occurrence No.9.
5. G-7-96 **Sulphide iron formation** - 1 km west of Hanes Lake - Occurrence No.5.

Table 10 continued

6.	G-7-97	Sulphides in banded chert/siltstone - 1 km west of Hanes Lake - Occurrence No.5.
7.	G-7-100	Banded sulphide iron formation - 1 km west of Hanes Lake - Occurrence No.5.
8.	G-7-101	Banded sulphide iron formation - 1 km west of Hanes Lake - Occurrence No.5.
9.	G-7-111	Banded sulphide iron formation - 2 km west of Hanes Lake.
10.	G-12-152	Sulphide/chlorite/chert iron formation - 1.6 km west of Teepee Lake.
11.	G-18-190	Magnetite iron formation - island in north part of Hanes Lake.
12.	G-27-234	Sulphide iron formation - 1.2 km west of Chubb Lake - near Occurrence No.7.
13.	G-44-351	Magnetite iron formation - Cowie Lake Section - Goulais River Iron Range Property No.1.
14.	A-3-46	Sulphides in ferruginous tuff - 0.7 km west of Chubb Lake.
15.	A-6-65	Sulphide/chert/amphibole iron formation - 2.6 km southwest of Teepee Lake - near Goulais River.
16.	A-6-90	Banded sulphide/chert/siltstone - 2.0 km west of Hanes Lake.
17.	A-7-94	Banded sulphides/chert/chlorite schist - 0.2 km southwest of Hanes Lake (southern end).
18.	A-20-165	Magnetite/siltstone iron formation - 1 km east of Hanes Lake (southern part).
19.	A-21-169	Magnetite/siltstone iron formation - east end of Hanes Lake (northern part).
20.	A-47-283	Hematite veins and blebs - Occurrence No.8 (McClintock).
21.	A-48-287	Lapilli-tuff and hematite veins - Occurrence No.8 (McClintock).
22.	A-55-304	Sulphide iron formation and massive sulphides in quartz veins and chlorite schists - Occurrence No.3.

Note: The analyses were made from grab samples collected in the field by the author and assistants.

To convert ounce/ton to gramme/ton (g/t) multiply by 34.2857.

TABLE 11 | QUALITATIVE SPECTROGRAPHIC ANALYSES OF SAMPLES FROM THE COWIE LAKE AREA. CHEMICAL ANALYSES BY GEOSCIENCE LABORATORIES, ONTARIO GEOLOGICAL SURVEY.

Sample Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	G-2-30	G-2-37	G-7-96	G-7-100	G-7-101	G-7-105	G-8-112	G-7-111	G-7-97	G-12-152	G-15-167	G-15-173	G-18-190	G-14-199	G-20-206	G-25-227	G-44-351	A-3-46	A-6-90	A-7-94	A-29-90	A-48-287	A-55-304
Antimony	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	T
Bismuth	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	TL
Cadmium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	T
Chromium	T	T	T	T	T	T	T	T	–	T	T	T	T	T	T	T	–	T	T	T	T	T	–
Cobalt	–	–	T	T	–	–	T	–	T	T	–	–	–	–	–	T	–	–	T	–	–	–	T
Copper	T	T	T	TL	TL	T	T	T	TL	T	T	T	–	T	T	T	T	T	T	T	T	–	–
Lead	–	T	T	T	T	–	–	T	T	–	–	–	T	–	–	–	T	–	–	–	–	T	H
Lithium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	T	–	–	–	–	–	–	–	–
Manganese	TL	T	T	T	T	TL	TL	T	T	TL	TL	TL	T	LM	TL	TL	T	T	T	T	TL	T	–
Molybdenum	–	–	T	T	T	–	–	T	–	–	–	–	T	–	–	–	–	T	T	T	–	–	–
Nickel	T	T	–	–	T	T	T	T	T	T	T	T	T	T	T	T	–	T	T	T	T	T	–
Silver	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	T
Titanium	TL	T	T	T	T	T	TL	T	TL	TL	LM	L	–	–	TL	L	TL	–	TL	TL	L	TL	–
Vanadium	T	–	–	–	–	–	–	–	–	–	T	T	–	–	–	T	–	–	–	–	T	T	–
Yttrium	–	–	–	–	–	–	–	–	–	–	T	–	–	–	–	–	–	–	–	–	–	–	–
Zinc	–	–	T	–	T	T	T	–	TL	–	–	–	–	–	T	–	TL	–	T	T	–	T	LM
Zirconium	–	T	–	–	T	T	T	–	T	T	T	T	T	T	T	T	–	–	T	–	–	T	–
Iron	MH	H	MH	MH	H	H	H	MH	H	H	H	H	H	H	MH	H	H	MH	MH	H	MH	H	L

Location of Samples:

1. G-2-30 Banded sulphides with interflow metasediments - 0.2 km west of Hanes Lake.
2. G-2-37 Banded sulphides in chert/quartzite iron formation 1.6 km north of Teepee Lake - Occurrence (9).
3. G-7-96 Sulphide iron formation 1 km west of Hanes Lake West Occurrence (5).
4. G-7-100 Banded sulphide iron formation - 1 km west of Hanes Lake West Occurrence (5).
5. G-7-101 Banded sulphide iron formation - 1 km west of Hanes Lake West Occurrence (5).
6. G-7-105 Interflow sulphide rich iron formation - 1 km west of Hanes Lake West Occurrence (5).
7. G-8-112 Sulphide/black chert/siltstone interflow iron formation 1 km west of Hanes Lake West Occurrence (5).
8. G-7-111 Banded sulphide iron formation 2 km west of Hanes Lake.
9. G-7-97 Sulphides in banded chert/siltstone - 1 km west of Hanes Lake West Occurrence (5).

Table 11 continued

10. G-12-152	Sulphide/chlorite/chert iron formation - 1.6 km west of Teepee Lake Occurrence (9).
11. G-15-167	Disseminated sulphides in hornblende/chlorite schist (mafic-flow) - 0.8 km east of Brown Lake.
12. G-15-175	Pyrrhotite in siliceous intermediate flow - 0.8 km southwest of Brown Lake.
13. G-18-190	Magnetite iron formation island in north part of Hanes Lake.
14. G-20-199	Banded magnetite/chert iron formation - 2 km north of Private Lake.
15. G-20-206	Graphitic magnetite iron formation sulphide matrix tuff 2 km N-NW of "Private Lake Occurrence" (HBOG Mining Ltd. [1976] (6)).
16. G-25-277	Sheared chlorite schist with pyrite - 0.6 km southwest of Forrester Lake Occurrence (HBOG Mining Ltd. [1976] (6)).
17. G-44-351	Magnetite/chert iron formation - Cowie Lake Section-Goulais River Iron Range-Property (1).
18. A-3-46	Sulphides in ferruginous tuff - 0.7 km west of Chubb Lake.
19. A-6-90	Banded sulphide/chert/siltstone - 0.2 km west of Hanes Lake.
20. A-7-94	Banded sulphides/chert/chlorite schist - 0.2 km southwest of Hanes Lake (southern end).
21. A-28-199	Fine-grained hornblende/chlorite schist in pillowed mafic metavolcanics-east end of Forrester Lake Occurrence (HBOG Mining Ltd. [1976] (6)).
22. A-48-287	Lapilli-tuff and hematite veins-McClintock Occurrence (8).
23. A-55-304	Sulphide Iron Formation and massive sulphides in quartz veins and chlorite schists - Occurrence No.3.

Abbreviations:						
H	10-100 percent	LM	0.5-5.0 percent	T	0.01-0.10 percent
MH	5-15 percent	L	0.1-1.0 percent	—	none detected
M	1-10 percent	TL	0.05-0.50 percent		

fine-grained greywacke, and metavolcanic tuff. Some of these banded units are brecciated, and the competent recrystallized chert and siltstone fragments are enclosed in a sulphide matrix. The sulphides are interbedded with the metasediments and suggest a syngenetic sedimentary depositional origin.

The sulphides are composed of fine- to coarse-grained (recrystallized) pyrite and pyrrhotite with minor amounts of chalcopyrite. Some of the sulphide iron formation were sampled and submitted for assay and spectrographic analyses and the results are shown in Tables 10 and 11. One sample that was assayed yielded 0.008 percent U_3O_8.

The sulphides are generally thinly bedded and massive sulphides are not common among most of the iron formations observed. Exceptions to this exist. In the section, "Description of Properties and Occurrences", Occurrences 3, 5, and 9 (see Map 2426, back pocket), in which banded sulphide iron formation and/or volcanic exhalative units exist, contain massive sulphides with chalcopyrite, galena, and sphalerite. Some of these sulphides contain silver and gold in varying amounts interbedded with the metasediments.

The area west of Cowie Lake and south of the Goulais River contains a considerable amount of felsic metavolcanic pyroclastic rocks in the form of tuff, lapilli-tuff, lapillistone, and pyroclastic breccia. South of the Goulais River where outcrop exposure is better than in most parts of the map-area, the pyroclastic breccias were observed to contain an occasional sulphide clast or have a rusty weathering matrix.

In the northwest and west-central parts of the map-area, electromagnetic conductors and subsequent drilling by HBOG Mining Limited have outlined interflow graphitic and sulphide-bearing horizons of the mafic to intermediate metavolcanic flows.

Iron

Iron in the form of Algoma-type oxide facies iron formation (Gross 1965) is by far the most significant and conspicuous type of mineralization within the map-area. Numerous magnetite-chert iron formations occur throughout the map-area, particularly west of Hanes Lake, west of Cowie Lake, and most notably east and south of Cowie Lake, where the Goulais River Iron Range occurs. Tables 10 and 11 show qualitative and quantitative assay results from grab samples of some of the iron formations.

Most of the oxide-type iron formations are thin (less than 2 m thick), and could not be traced far along strike (less than 1 km). These units are interpreted as local basinal units of deposition within the metavolcanic environment. It was noted by the author in the field that the thicker units of oxide-facies iron formation are often associated with underlying mafic metavolcanic flows and overlying felsic metavolcanic tuffs. This may be interpreted as a quiet period within the volcanic environment during which the chemical and fine-grained clastic sediments accumulated.

The iron formations occur as banded magnetite-chert beds varying from 2 mm to 1 cm in thickness. The magnetite is usually black with fine- to medium-grained (recrystallized) chert interbedded within it. The magnetite laminae vary

from black to grey to reddish grey, depending upon the amount of chert and hematite that occurs within the individual laminae. Likewise, the chert is variable from white to dark grey, dependant upon the amount of magnetite, hematite, and other silicate minerals that are present. Some laminae show grading from chert to magnetite over a thickness of 1 cm. However, most of the laminae boundaries are abrupt. The occurrence of jasper in the iron formations is restricted to the north end of the Goulais River Iron Range, and is probably metamorphic in origin. Jasper is generally rare in the iron formations of the southern Batchawana area (Moore 1925, p.18).

Recrystallized chert is common in the more thinly bedded oxide and sulphide facies iron formations. The chert is often rusty in appearance and is friable and uncohesive to the point that it may be crushed in one's hand. This was not observed in the thicker iron formations.

Hematite in the form of patches and seams (McClintock Occurrence (8)[1]) occurs within the gneissic felsic metavolcanics and granitic rocks east of Point Lake. The amount of hematite is insignificant, and its origin may be from assimilated oxide facies iron formation or from a hydrothermal source.

Pyrite is another source of iron in the map-area, occurring in the sulphide iron formations as mentioned previously. The amount of iron is insignificant in terms of economic potential.

Quartz Veins

Quartz veining is common throughout the map-area, and is particularly well exposed in the Goulais River area west and south of Teepee Lake. The veins are usually only a few cm thick and less than 10 m in length. They commonly occupy tension fractures and fractures parallel to the regional foliation of N50°W. The veins do not show any sulphide mineralization and appear to be barren. No samples were selected for assay.

Description of Properties and Occurrences

THE ALGOMA STEEL CORPORATION LIMITED, ALGOMA ORE DIVISION; GOULAIS RIVER IRON RANGE (1)[1]

History of Development

The Algoma Steel Corporation Limited holds a leased parcel of land in the northwest corner of Nahwegezhic Township extending southward to Annibal Lake and a parcel of six patented claims numbered SSM 14052 to 14057 inclu-

[1]The number in parentheses refers to property list on Map 2426, back pocket.

sive, in the northeast corner of Lunkie Township on which the Goulais River Iron Range is located (Figure 8).

Exploration started as early as 1910 at which time a considerable amount of iron formation was removed for testing and taken to the Bureau of Mines in Ottawa (Moore 1925, p.18; ODM-IOC, 1923, p.196). The township was originally controlled by the Algoma Central Railway (ACR) and nine claims were staked (Assessment Files Research Office, Ontario Geological Survey, Toronto; AC 414 to 422 inclusive and were later leased in the Cowie Lake area in 1921 (L. Oliphant, Algoma Central Railway 1977, personal communication). These claims are not shown on Map 2426, back pocket. When control of the township reverted back to the Crown, the claim group remained part of the company's holdings. To the north, the McPhail Deposit (The Algoma Steel Corporation Limited, Algoma Ore Division; McPhail Deposit (2)) adjoins the Algoma Central Railway holdings and consists of a group of nine patented claims SSM 1289 to 1297 inclusive, in the southwest corner of Gaudry Township. The Algoma Steel Corporation Limited leased the parcel of land around the Algoma Central Railway claims and in 1934 leased the claims from the Algoma Central Railway. The McPhail property, also known as the Sligh Property or Hillier Claims, was also leased to the Algoma Steel Corporation Limited.

In 1941, a major exploration programme that commenced on the Cowie Lake section of the iron range continued until 1944, and during this time the southern extension as far south as Annibal Lake was located. By 1944, 228 diamond-drill holes had been put down on the iron range for a total of 39 324 m. Of these holes, 157 had been drilled in the Cowie Lake section (Figure 8) for a total of 29 404 m (Moore and Armstrong 1946). An additional diamond-drilling programme was carried out from 1963 to 1966 along the section east of Gut Lake on which 20 diamond-drill holes were put down for an additional 1283 m (Algoma Central Railway Files, 1977). Trenching and beneficiating studies were carried out in the Cowie Lake section of the Iron Range.

Geology of the Goulais River Iron Range

The Goulais River Iron Range consists of a sequence of banded chert-magnetite iron formations with interbeds of mafic to felsic metavolcanic flows, tuffs, felsic metavolcanic pyroclastics and minor amounts of clastic metasediments. The iron range is underlain by amphibolitized (hornblende-hornfels facies; Winkler 1976) tholeiitic mafic metavolcanic pillowed flows that are in contact with the granitic rocks to the east. The minimum thickness of these mafic metavolcanics is approximately 400 m. Iron formation occurs within these metavolcanics at the top of the sequence. The iron formation is for the most part situated in felsic metavolcanic tuffs and flows intercalated with minor amounts of thinly bedded clastic metasediments. Overlying the iron formation, the rocks are primarily rhyolitic tuff flows (Figure 8).

The author has interpreted the Goulais River Iron Range as an indicator of the paleoenvironment that existed at the time of deposition. It appears that the volcanic environment began to change following the extrusion of the lower tholeiitic mafic metavolcanic sequence that underlies the iron formation. Extrusion

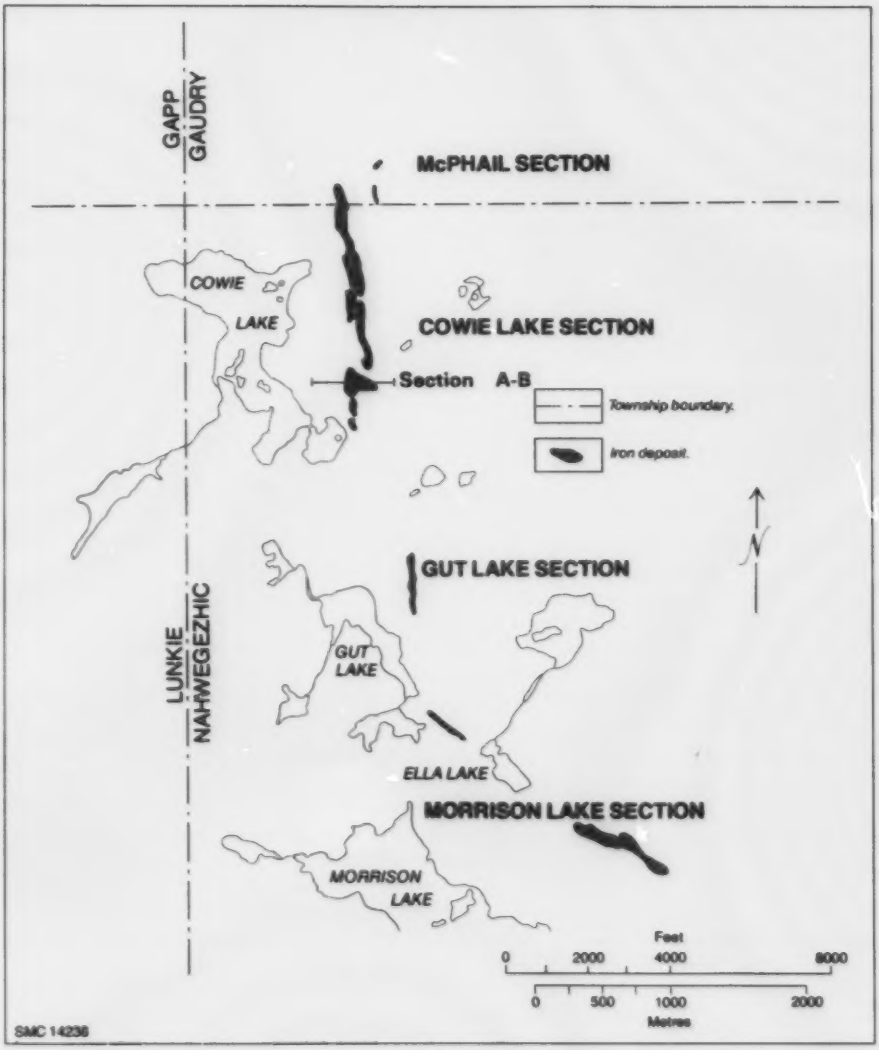


Figure 8–Plan map of the Goulais River Iron Range.

and ejection of volcanic material became infrequent, and in this period of relative quiescence, the iron formation accumulated in local water-filled basins. An influx of minor clastic sediments derived from weathered volcanic rocks, felsic, intermediate and mafic tuffs, and minor mafic and/or felsic metavolcanic flows occurred sporadically throughout the iron formation deposition. This period of chemical sediment accumulation marks the change from a tholeiitic mafic volcanic environment to a calc-alkalic intermediate to felsic metavolcanic environment. Magnetite rich fine-grained tuffs are common within the iron formation indicating that pyroclastic debris from minor volcanic activity accumulated while the chemical deposition occurred. The felsic metavolcanic interbeds vary from a few mm to 3.0 m in thickness. Thin beds of arkose and stratified tuff also occur interbedded within the iron formation, these beds probably represent sorting which took place as the pyroclastic material fell through the water (Moore and Armstrong 1946, p. 24). The mafic metavolcanic flows are usually pillowed and less than 3 m in thickness. Westward, towards Cowie Lake, the felsic metavolcanic pyroclastic rocks become coarser in clast size and are pyroclastic breccia in places. Felsic metavolcanic flows are more common in this area.

Southward, in the vicinity of Ella and Annibal Lakes, the clastic metasediments and mafic metavolcanic flows are the host of the iron formation. The metasediments are immature, volcanically derived arkose and greywacke, and the iron formation underlies these rocks.

The Goulais River Iron Range is bounded to the north by the Goulais River and extends as far southeast as Annibal Lake. Although no iron formation was located during traverses made southeast of Annibal Lake, the aeromagnetic map (ODM-GSC 1963) indicates a magnetic extension southward into the migmatitic and metasomatic metavolcanics that becomes granitic in character. To the north, the iron formation terminates at the Goulais River Fault. Isolated blocks of the iron formation up to 5.0 m across were found by the author in highly sheared felsic metavolcanic schists in the fault zone. Northward towards Hanes Lake, isolated magnetite-chert iron formations were located. However, it is not known if these units are equivalent extensions of the Goulais River Iron Range or represent entirely different periods of iron formation deposition. East of Hanes Lake and on a small island at the north end of Hanes Lake, an iron formation of more significant size was observed by the author. This unit thickens northwestward into what is known as the Central Goulais River Iron Range located north of Butter Tin Lake (Siragusa 1978a and b). It is possible that the area between the Goulais River and Hanes Lake was an area in which the paleogeography or volcanic activity prevented the accumulation of significant amounts of iron formation, that is if there is any time-stratigraphic correlation along the Goulais River Iron Range.

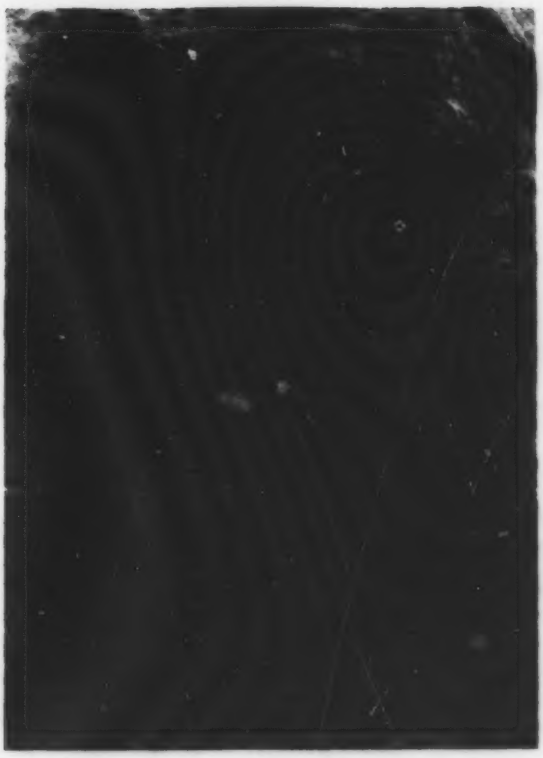
The Goulais River Iron Range is nearly 6000 m in length and varies in thickness from 10 cm to 200 m across, although the widest band of iron formation is about 83 m at the surface. Diamond drilling has located the iron formation at a depth of more than 300 m below the surface. However, the bands are irregular in thickness and length throughout the deposit due to the variability in supply of material during deposition, syngenetic slumping, and folding, and the intrusion of the numerous diabase dikes. The strike of the strata is predominantly NNW and dips are vertical to 80°W.

Moore and Armstrong (1946, p. 28) described the iron range as follows:

> From Cowie Lake south to a point opposite the north end of Gut Lake, the range presents little of economic interest. Three holes were drilled in a locality about 1,000 feet [300 m] southwest of Cowie Lake where a band of siliceous magnetite widens out. The results were disappointing because the ore body is shallow and pinches out rapidly to the south. In fact, the iron formation almost disappears in a section beginning about 500 feet [150 m] south of these holes, and only a few small bands or lenses occur for a distance of about 1,400 feet [430 m] along the strike of the range. Here the iron formation passes under drift for another 1,400 feet [430 m], except for one small outcrop in the green timber area shown on the accompanying map of the Dude-Gut Lakes section [see Map No. 1946-4b *in* Moore and Armstrong 1946]. The presence of magnetite, however, was shown by the dip needle. Recent drilling has indicated a band of siliceous magnetite from 60 to 174 feet [20 to 53.0 m] wide in this part of the range. On the southwest edge of the woods, a band of good siliceous magnetite about 60 feet [20 m]wide is exposed, but the iron formation splits up to the south.
>
> Just east of Dude Lake, a band of ore 60 feet [20 m] wide has been drilled for about 1,000 feet [300 m] along its strike. It is mostly covered with drift. Around Ella Lake, the iron formation is disappointing; it contains only narrow bands of magnetite separated by beds of sediment and tuff. One large band occurs in an outcrop at the southeast corner of the lake, but it pinches out quickly underground. This band is enlarged by duplication of beds due to a small fault.
>
> Between Ella and Annibal Lakes the iron formation is wide, but the siliceous magnetite is split up into numerous bands some of which are separated from each other by thick beds of tuff or sediment. This part of the range is heavily drift-covered in many places; it has been extensively drilled but on the whole has been found to be much less promising than the Cowie Lake section of the range. A zone extending about 1,500 feet [460 m] northward from a point opposite the outlet of Annibal Lake, however, contains a considerable amount of ore. It is cut by several diabase and granite dikes, and the ore is shallow at the south end where the granite undercuts it.
>
> Banded silica is the most abundant mineral in the ore. The bands usually range from a sixteenth to a quarter of an inch [1.6 to 6.3 mm] in width, but some are narrower and some wider than this, the maximum width probably not exceeding half an inch [1.2 cm]. They are black, grey, or green in colour and a few are composed of red jasper. The colour of the green bands is due to hornblende or actinolite. A considerable amount of grunerite, a brownish-coloured amphibole, occurs in some sections. The silica bands vary greatly in the size of grain. Some very fine grained ones alternate with much coarser ones, the larger grains being as much as ten times as large as the smaller ones. The distribution of the magnetite varies considerably. In some thin sections it occurs nearly evenly distributed as small specks all through both coarse and fine silica, with bands of larger grains. In others, more magnetite occurs in the finer grained layers both within and between the grains of silica.

Examination of thin sections shows that the chert is recrystallized in some bands while it is not in others. The coarse grains of quartz are polygonal in shape and contain some interstitial hematite. Grunerite appears to be exclusively associated with the magnetite rich bands as small lenses and laminae parallel to the bedding. Grain size of the chert and magnetite varies from 0.02 mm to 0.15 mm.

The bedding of the iron formation varies from regular rhythmic banding to highly irregular contorted banding as seen in Photo 12. Much of this deformation probably occurred during diagenesis due to slumping. Many of the outcrops examined show *en-echelon* slip and shearing along planes vertical to the banding. Deformation of this type is most probably tectonic in origin, during the deformation of the Batchawana Belt. Structurally, the iron range is complicated, partly due to diagenetic deformation and partly to the tectonic movement of the larger felsic and mafic metavolcanic units. Moore and Armstrong (1946, p.224-28) discussed the folding of the iron formation in detail. The authors proposed that a large fold existed in the Cowie Lake section of the iron range that plunged to the north. An expression of the attitude of the iron formation is shown in Figure 9. Numerous diabase dikes have intruded the iron formation. This is possibly due to the fact that the iron range is near to the granitic margin of the belt, mak-



OGS 16082

Photo 12–Folding in the magnetite-chert iron formation in the Goulais River Iron Range, 1.0 km east of Cowie Lake.

ing it a zone of weakness into which the diabase might have intruded more easily.

Figures 8 and 9 show a plan map of the iron range and a cross section at the north, central, and southern part of the Cowie Lake section in which the author has interpreted the distribution of the iron formation from drill hole information.

E.S. Moore and H.S. Armstrong (1946, p.32, 33) described the quality of the iron ore as:

> The analyses show that what is regarded as material that may be mined runs between about 25 and 40 per cent total iron. Across the orebodies drilled, most of the ore averages from 30 to 32 percent total iron and is regarded as of commercial importance. The magnetic iron mostly runs between 3 and 4 per cent less than the total iron, although it may be considerably higher or lower than this in some ore bodies. Results of experiments on concentration of the ore show that some of the iron not contained in magnetite is also recovered, which somewhat increases the total recovery.
>
> The phosphorus in the raw ore is quite uniform in distribution, and it generally runs between 0.05 and 0.06 per cent. As the phosphorus is reduced to about 0.023 per cent, in the concentrate, some of it

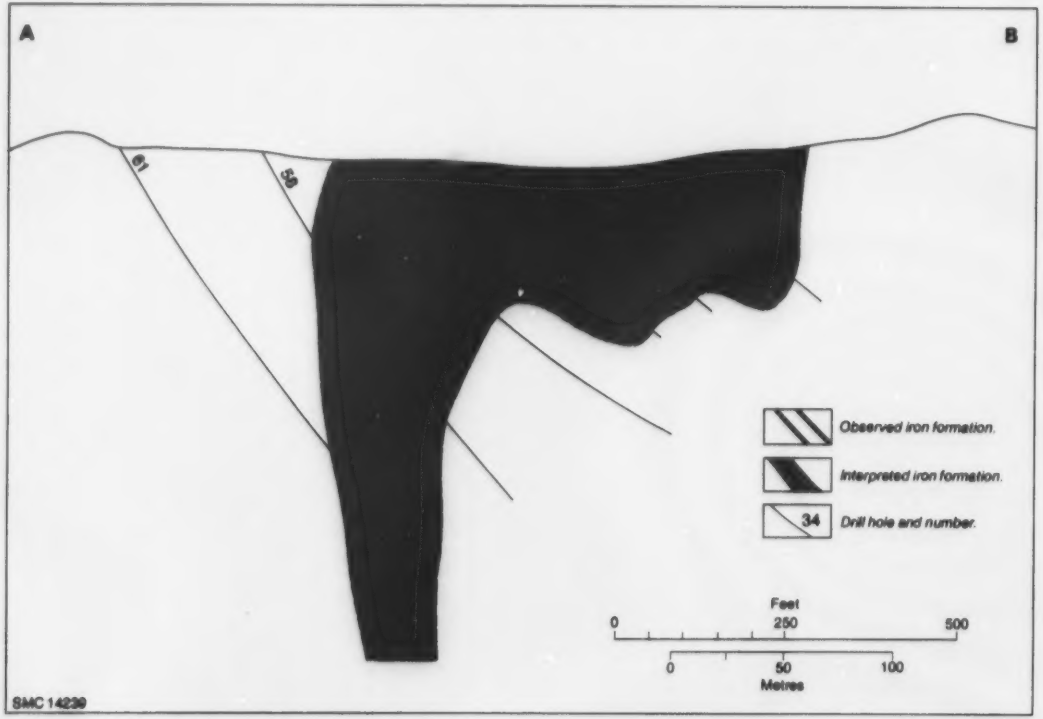


Figure 9–Cross section of the Goulais River Iron Range.

at least appears to be associated with the silica. In most of the ore, sulphur is less than 1 per cent, but in spots it is high. Sulphur in the form of pyrite has been introduced into the iron formation near some dikes. The pyrite will not be at all objectionable if the concentrate is sintered and will even reduce the cost of fuel in the process.

Pyrite was observed by the author within the lower units of the iron formation, associated primarily with the mafic metavolcanics. The author believes that some of this pyrite may be syngenetic in the form of intermittant, local amounts of sulphide iron formation.

No tonnage estimates of ore are available, but it has been estimated that there are approximately 30 480 000 tonnes (30,000,000 long gross tons) of iron pellets available (Canadian Mines Handbook 1977/78, p. 24) in the Cowie Lake Section of the iron range.

THE ALGOMA STEEL CORPORATION LIMITED, ALGOMA DIVISION; McPHAIL DEPOSIT (2)

The McPhail Deposit is the northernmost extension of the Southern Goulais River Iron Range and is covered by nine patented claims, SSM 1289 to 1297 inclusive, in the southwest corner of Gaudry Township. The property has previously been known as the Sligh Property or Hillier Claims (Shklanka 1968).

The geology of the deposit is much the same as that of the iron formation to the south namely the property of the Algoma Steel Corporation Limited, Algoma Ore Division; Goulais Iron Range (1) . The iron formation is not as wide as to the south and is composed of two diverging units, one trending northwest, the other trending northeast. The divergence may be due to the many diabase dikes that have been intruded (Moore and Armstrong 1946) into the formation.

Diamond drilling was carried out in 1922 at which time seven holes totalling 838.2 m in length were put down (Shklanka 1968, p. 43). No work has been done on the property since 1922, and Moore and Armstrong (1946, p. 33) stated that the ore reserves estimated at that time were roughly 500,000 long gross tons for each 30 m in depth, averaging 31 percent Fe with a possible 5 080 000 tonnes (5,000,000 long gross tons) to a depth of 120 m. The property is now controlled by the Algoma Steel Corporation Limited.

BRENNAN OCCURRENCE (3)

In 1967, L.T. Brennan of Toronto, prospecting on behalf of J. Hamilton of Toronto, made a discovery of lead-zinc-silver-copper mineralization in Gapp Township approximately 2 km west of Chubb Lake. The claims were acquired by World Mining Explorations Limited and an associated company, Victoria Algoma Mineral Company Limited (Giblin and Leahy 1967). The mineralization occurs in several zones, varying in width up to 10 m and approximately 0.5 km in length which are parallel to the regional foliation of N50°W and dip vertically. Pyrite, pyrrhotite, galena, sphalerite, and chalcopyrite occur in quartz veins

within cherty and graphitic interflow metasediments within the felsic metavolcanics. A grab sample containing massive galena was submitted for assay and gave values of 0.034 percent copper, 1.4 percent zinc, and lead as shown in Tables 10 and 11. The quartz veins have intruded and brecciated the dark grey cherty siltstone and sulphide iron formation. The mineralization occurs as massive areas and disseminations in the quartz veins. An electromagnetic survey followed by a trenching programme was carried out (Assessment Files Research Office, Ontario Geological Survey, Toronto). At least five diamond-drill holes were bored. No further information was recorded, and the claims were allowed to lapse.

HANES LAKE NORTH OCCURRENCE (4)

This occurrence is located approximately 0.5 km northwest of Hanes Lake on the Domtar Road and consists of a rusty weathering, recrystallized sulphide chert iron formation striking approximately N50°W and dip vertically. The chert is sugary and friable in texture and the unit is approximately 1 m thick. It is underlain by mafic to intermediate metavolcanics and overlain by felsic to intermediate lapilli-tuff. The length of the unit is unknown. This unit is typical of many of the minor sulphide iron formations that occur interlayered with the mafic to intermediate metavolcanics in the north-central part of the map-area. A grab sample collected by the field party indicates 0.10 percent copper, and 0.03 ounce per ton gold and trace silver (Table 10). The sulphides appear as a rusty weathered zone composed of about 10 percent massive pyrite. Minor chalcopyrite was observed.

HANES LAKE WEST OCCURRENCE (5)

This occurrence consists of a mineralized area about 1.0 km west of Hanes Lake and is accessible via the Domtar Road. The occurrence contains minor copper and silver values with traces of lead, nickel, and gold. Unreported trenching has been carried out on the occurrence. The mineralization is not restricted to any one zone, but rather a number of interflow metasedimentary units in which sulphide iron formation and magnetite iron formation are common. These units strike N50°W and dip 80° to the north. The mineralization occurs in a rusty gossan-like weathered sequence of graphite, argillite, chert, siltstone, and chlorite schist interbedded with mafic to intermediate pillowed flows. Visible mineralization consists of pyrite and pyrrhotite occurring in massive and disseminated forms within black and white chert, parallel to the bedding. The cherty units were observed to contain thin laminae of argillite similar to the nearby iron formations. Calcite rhombs up to 2.0 cm in diameter were found in one trench which displayed intense shearing in the wall rocks. The width of the mineralized zone is approximately 100 m. Westward along a bush trail towards Red Pine Lake, at least two more trenches were located that were about 2 m in length and 1 m deep. It is not known how far south or north the zone extends across the

stratigraphy. Six grab samples from this area were assayed and the results given in Tables 10 and 11. One sample indicated 0.12 percent copper, 0.01 percent lead, 0.02 percent nickel, 0.23 ounce per ton silver, and trace gold.

HBOG MINING LIMITED [1976] (6)

In 1975, HBOG Mining Limited performed an airborne electromagnetic survey over Gapp and Lunkie Townships for a total of 615 line miles of flying with the subsequent staking of 198 claims. Conductive horizons up to 4.5 km in length were traced out by the survey. The anomalies are generally parallel to the regional foliation although a few are parallel to the northeast-trending faults. A ground geophysical survey followed by a trenching and drilling programme was carried out during the field season of 1976 (Karl Giesbrecht, HBOG Mining Limited, personal communication 1976). Ten diamond-drill holes were drilled for a total length of 512 m and trenches were dug in 53 localities (HBOG Mining Limited, 1977, company files). Drill logs from the area just east of the Goulais River, west of Cowie Lake, show that the conductors are chiefly graphitic and argillaceous units representing interbedded metasediments within felsic to intermediate pyroclastic metavolcanics comprising dacitic to rhyodacitic fine-grained tuff with minor interflows of more mafic metavolcanics. The graphitic horizons commonly contain pyrite, pyrrhotite, and trace to minor amounts of chalcopyrite occurring as stringers, blebs, and veinlets as shown in trenches and diamond-drill logs that were examined by the author. Northwest of Teepee Lake, approximately 1.5 km northwest of the Goulais River, two diamond-drill holes intersected minor amounts of disseminated pyrrhotite at a depth of approximately 48.7 m within mafic to intermediate metavolcanic tuffs and flows of calc-alkalic andesitic composition. Approximately 1.2 km to the south of this area, a graphitic massive sulphide zone was intersected in a drill hole about 0.25 m thick and was found to contain pyrite and pyrrhotite within andesitic flows. West of the Goulais River and south of Forester Lake, there are numerous graphitic horizons and minor sulphides have been reported.

In the southwest corner of the map-area, a diamond-drill hole (HBOG Mining Limited, Company files) indicates pyrrhotite and trace amounts of chalcopyrite in a zone 2 m in width and a few metres in length within amphibolitized mafic to intermediate mafic metavolcanics with an assay value of 0.05 percent copper over a core length of 0.5 m. In the northwest part of the map-area, south of the Chippewa River, graphitic conductors within a mafic to intermediate metavolcanic sequence of flows, contain disseminated pyrite and trace chalcopyrite as indicated in diamond-drill logs.

Many pyrite, pyrrhotite, and graphite conductors were trenched throughout the area, most of them occurring in felsic metavolcanic tuffs that occur in the central and south-central parts of the map-area.

The results of the ground work were not encouraging and the claims were allowed to lapse during the summer of 1977.

HUMBLEFORD EXPLORATION LIMITED [1968] (7)

In 1968, Humbleford Exploration Limited carried out a ground magnetic and electromagnetic survey over a group of 18 claims in Gapp and Gaudry Townships west of Point Lake near the granite-metavolcanic contact. No mineralization was noted and the results of the survey were not encouraging. No further work was reported and the claims were allowed to lapse.

McCLINTOCK OCCURRENCE (8)

Four occurrences of hematite exist near the centre of Gaudry Township, approximately 1.5 km east of the southern end of Point Lake. The hematite occurs in seams and patches within pegmatitic granite over an area of approximately 1.0 km^2 (ODM-IOC 1923, p.196; Shklanka 1968) and the author has noted that some of the mineralization occurs within foliated and recrystallization felsic metavolcanics that strike N80°E and dip vertically. Veins of massive hematite appear to be more common than massive patches and this appears to comprise as much as 5 percent of the rock in places. The origin may be related to assimilation of iron formation by metasomatism or it may be hydrothermal in origin. Grab samples collected by the author from two localities were assayed and are presented in Table 10. The hematite is massive in appearance and relatively free of gangue material (ODM-IOC 1923, p. 196). However, the amount of mineralization is insignificant for an economic consideration to be made at this time.

TEEPEE OCCURRENCE (9)

This occurrence is west of Chubb Lake and about 1.6 km north of Teepee Lake. The visible mineralization consists of massive to disseminated pyrite with a brecciated and recrystallized banded chert which is probably a brecciated sulphide iron formation. The unit strikes at approximately N50°W, dips 80°N, and is underlain by pillowed mafic to intermediate metavolcanic flows and is overlain by lapillistone of felsic to intermediate metavolcanic composition. The unit is approximately 1 m thick and was traced for about 200 m to the northwest. A grab sample collected by the author was assayed (Table 10) and indicates 0.12 percent copper, 0.01 percent lead, 0.02 ounce per ton gold and trace silver. A qualitative assay for other metals is shown in Table 11.

Recommendations for Future Mineral Exploration

Base-metal exploration has probably not received enough attention in the map-area. The author believes, on the basis of examination of the occurrences observed, that there is a possibility of additional mineralization. The area west

of Hanes Lake was noted by the author to contain many minor mineralized bands of sulphides and some of these are probably exhalative in origin. Further exploration may uncover additional mineralization. Although the former World Mining and Exploration property (Brennan Occurrence (3)) has been explored by drilling and trenching, further exploration may be warranted. The area southeast of the Goulais River and west of Cowie Lake may be a potential target for further exploration. In this area, the author noted that pyroclastic breccias with minor sulphide clasts are interbedded with felsic and mafic metavolcanic flows. Although outcrop exposure is poor in this area, the author has interpreted the area to be primarily that of a felsic pyroclastic environment and that it has potential for the discovery of syngenetic volcanic sulphide deposits. Airborne electromagnetic surveys indicate that numerous electromagnetic anomalies occur throughout the area, and these anomalies have been investigated to some extent. However, the author believes that additional work may reveal more sulphide mineralization.

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MAPS
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